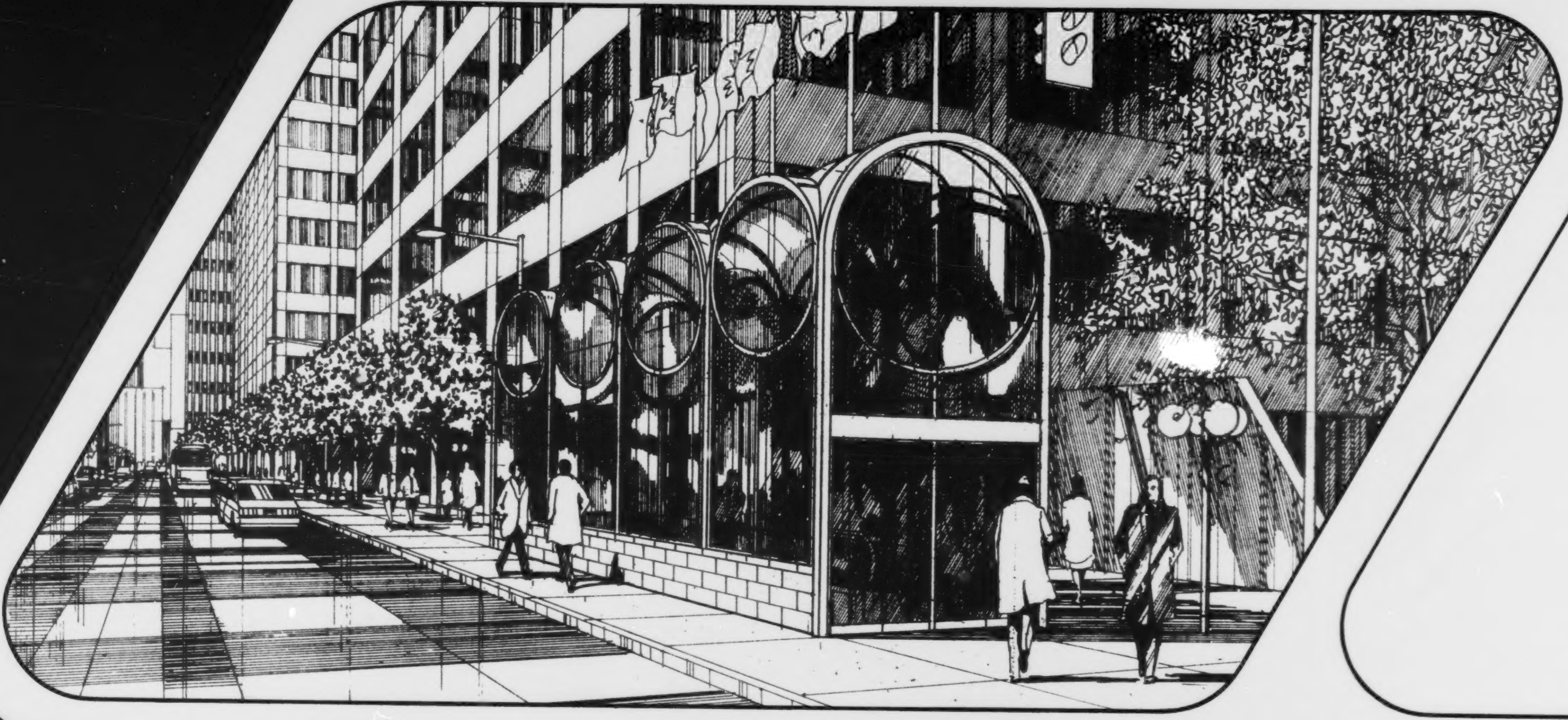

# RMOC
# CENTRAL AREA TRANSITWAY
# GRADE-SEPARATION FEASIBILITY STUDY

# REPORT ON THE FEASIBILITY OF A GRADE SEPARATED TRANSITWAY THROUGH THE CENTRAL AREA OF OTTAWA

PREPARED FOR

REGIONAL MUNICIPALITY OF OTTAWA-CARLETON
TRANSPORTATION DEPARTMENT
TRANSITWAY DIVISION

BY

**DELCAN CORPORATION**

DECEMBER 1988

04-1725-B-00

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DELCAN
ENGINEERS
PLANNERS
ARCHITECTS
35 YEARS

1989 02 14

Our Ref.: 04-1725E-00

Mr. Ian G. Stacey, P.Eng.
Director, Transitway Programme
Regional Municipality of Ottawa-Carleton
222 Queen Street
Ottawa, Ontario
K1P 5Z3

Dear Mr. Stacey:

Re: Central Area Transitway Grade Separated Feasibility Study

This report documents the findings and conclusions of our study of various concepts that may be used to grade separate the transitway through the Central Area for a distance of approximately 3 km between Campus Station and the proposed Lebreton Station at Booth Street. As set out in the study scope, we investigated both above and below ground options and made use of all data that were generally available to us.

Various alternatives for each of the elevated, cut-and-cover and tunnel concepts were developed and tested against a wide range of criteria. From this evaluation, a preferred option for each of the three main alternatives, i.e., elevated, cut-and-cover and tunnel was identified. Further refinement of these options and more detailed evaluation led us to identify the twin tunnel option as the overall preferred option.

This preferred option involved a twin tunnel concept, with eastbound buses under Albert Street and westbound buses under Slater Street, connected at stations by a tunnel mezzanine under the cross streets. Four stations are recommended, located approximately at Rideau Centre, Metcalfe, Bank and Lyon Streets.

This option had the primary advantage of offering the least on-street disruption to Central Area activities during the three to four year implementation period.

A number of special studies are needed now in association with the functional design process to refine the preferred option, confirm property requirements and prepare pre-design drawings and baseline budget estimates.

We believe that the preferred option will provide a much improved transitway link through the busy Central Area. This facility will provide significant benefits to the transit passengers, OC Transpo, other road users, the business, commercial, and retail interests in the Central Area and assist in maintaining the strong central core of the Region.

Our team of consultants included specialists in their fields drawn from Canada, the United States and Europe. Their tasks were made easier by the high level of cooperation and support we received from staff at Regional Municipality of Ottawa-Carleton, the City of Ottawa, representatives of the various utility companies, and others who each made a contribution to the total effort. While acknowledging the support received from others, the responsibility for the study rests with Delcan Corporation.

We trust that you will find the report provides you with the information required to allow you to advance the project to the next phase. We are prepared to assist you in the explanation and presentation of our findings to your Council.

Thank you for the opportunity to participate in this most exciting and important project, and we look forward to continuing our association with the Region on this project.

Yours very truly,

R Wayne Bowes

R.W. Bowes, P.Eng.
Vice-President, Transportation
Project Manager

J.A. MacNiven, P.Eng.
Manager, Ottawa Operations

RWB/JAM:sb

**DELCAN CORPORATION**
2001 THURSTON DRIVE, P.O. BOX 8004, OTTAWA, ONTARIO, K1G 3H6 • (613) 738-4160 TELEX 06-9666-69
FAX: (613) 739-7105
ST. JOHNS, TORONTO, MONTREAL, HAMILTON, NIAGARA FALLS, LONDON, THUNDER BAY, WINNIPEG, REGINA, SASKATOON, EDMONTON, CALGARY, VICTORIA, NEW WESTMINSTER, CHILLIWACK, NANAIMO, PORT ALBERNI

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# PREFACE

This report was prepared by Delcan Corporation for the Regional Municipality of Ottawa-Carleton in fulfillment of a contract awarded to Delcan as a result of a national competition. The first four chapters constitute a Summary of the study and have been produced separately as a Summary Report. The summary and the remaining chapters of the full technical report provide details on the many technical studies carried out by the Team Members.

This study was a concept feasibility study whose objective was to identify the feasible options to grade separate the transitway between the current Campus station at the University of Ottawa, through the downtown of Ottawa to the proposed transitway station in Lebreton Flats at Booth Street. Both elevated and underground options were to be investigated.

The results of this study provide input required by the Regional Municipality to develop an implementation strategy for the Central Area Transitway. Significant additional engineering work is required to refine the recommended concept and to conduct the special studies necessary to resolve some of the issues prior to a decision on implementation.

# ABSTRACT

The Ottawa-Carleton Regional Transit Commission (OC Transpo) operates a public transit system within the Regional Municipality of Ottawa-Carleton (RMOC) with over 800 buses and annual ridership in excess of 81 million revenue passengers. This is one of the highest ridership levels of any North American city. An exclusive bus transitway, initially 31 kilometres long, is a key element in the public transit system. Currently, almost 20 km of the Transitway are in operation, and the balance is either under construction or in the planning and design phase. The Central Area portion of the Transitway, 3 km in length, operates at-grade on twelve hour exclusive bus lanes on Albert St., Slater St. and the MacKenzie King Bridge. Increasing bus and vehicular traffic volumes in the Central Area have led to deteriorating transit surface operating conditions. This is in marked contrast to the relatively high speed of bus transit operation on the existing Transitway east and west of the Central Area. This difference is obvious to the transit users.

The Rapid Transit Implementation Plan adopted in the mid 1970's recognized the eventual need for a grade separated transitway through the Central Area. The overall implementation strategy was to construct grade separated transitways outside the Central Area first, before proceeding with the Central Area portion[1]. The plan anticipated the need for a grade separated Central Area section by the mid-1990's. In accordance with that plan, the RMOC and OC Transpo have envisaged a grade separated transitway through the Central Area to connect the eastern and western portions of the Transitway. This study is a continuation of the Rapid Transit Implementation Plan and has considered three options to achieve grade separation: elevated, a below ground facility constructed using cut and cover construction techniques or a tunnel using boring or drill and controlled blast technology, (New Austrian Tunnelling Method, NATM).

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[1] Rapid Transit Appraisal Study, February, 1976.

The alignments studied for each option identified all technically feasible possibilities. All alignments were investigated for impacts on the urban environment, bus and vehicular operations. A preliminary screening was conducted to short list the initial alternatives for each option. The remaining alternatives for each option were then subjected to more detailed examination in the second phase of the study and a preferred alternative selected for each option.

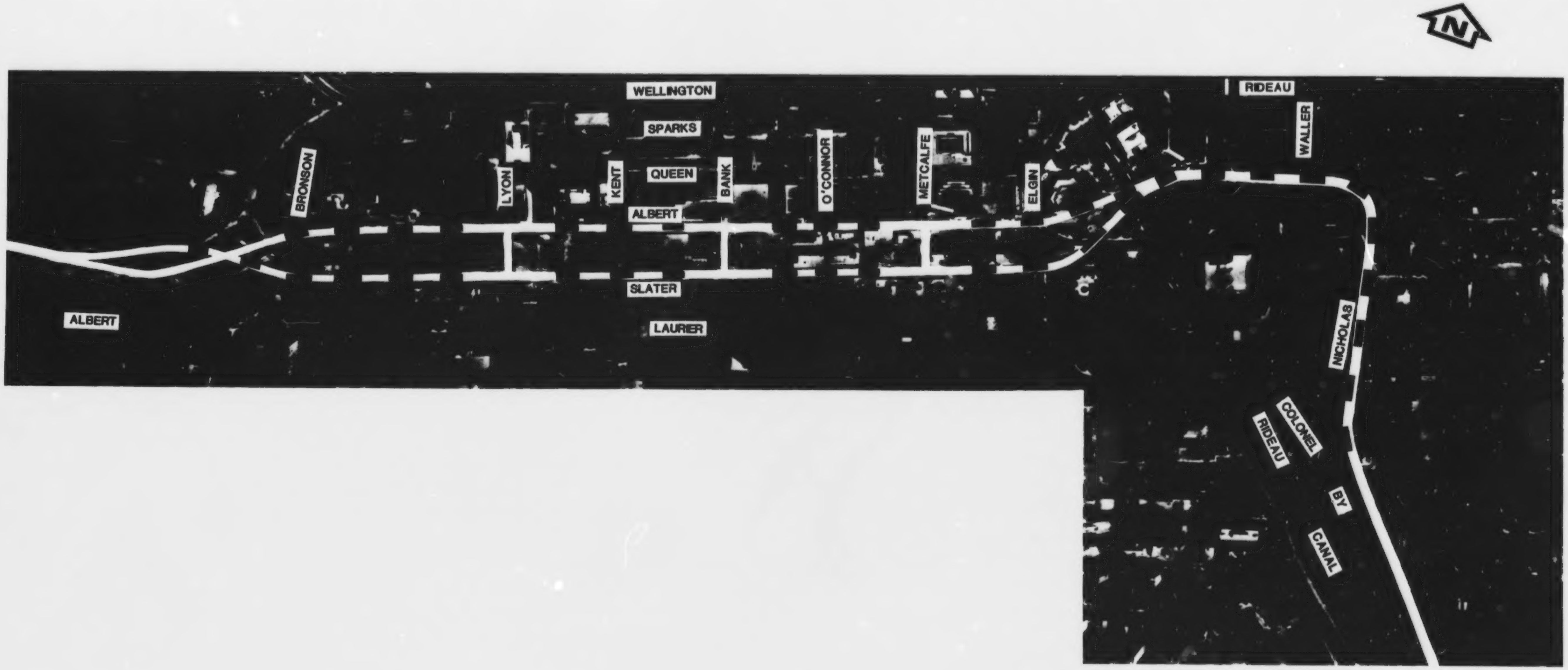
The preferred elevated option begins to climb just north of the Campus Station, proceeds over Laurier Avenue to a station just east of the Department of National Defence Building (DND) and south of the MacKenzie King Bridge. The elevated Transitway passes through the northern most part of the DND, on the south side of the MacKenzie King Bridge, across the northern portion of Confederation Park, and over Elgin Street. From there, the elevated Transitway passes through the western portion of the Central Area at 10 m above Slater Street. Four stations are included in the Central Area; Rideau Centre, one in the Metcalfe-Elgin Block, one at Bank Street, and one just west of Lyon Street. At the stations, the elevated Transitway would cover almost the total street for the 110 m length of the station. The elevated transitway proceeds west from the station at Lyon Street and passes over the Bronson-Portage alignment and then descends on a long 3 1/2 percent grade to a station at Booth Street which would be some 10 to 15 metres above grade. West of the station, the Transitway continues at 3 1/2 percent grade to reach existing ground level at Champagne Street.

The preferred cut and cover option begins to depress north of the Campus Station as a twin tunnel passing under Laurier Avenue and into a gentle curve into the Daly Street alignment where a station is developed which has direct access into the Rideau Centre. From there the alignment swings north passing under the Rideau Canal and north of the National Arts Centre. The two bus tunnels cross over each other with the westbound tunnel going under Albert Street and the eastbound tunnel under Queen Street. West of Bronson the two tunnels cross over each other again and proceed to the Lebreton Station at Booth Street. Stations would be developed at the Rideau Centre, at Metcalfe Street, at Bank Street and at Lyon Street. This tunnel configuration allows the buses to unload/load passengers and avoid an intermediate mezzanine level.

The preferred rock tunnel option shown on Exhibit A.1 and the recommended overall option is a twin tunnel Transitway beginning at the existing Campus Station. A twin tunnel configuration is preferred so that each direction of travel can be developed entirely under the street right-of-way, even at the stations, and thus avoid property easements and potential underpinning of buildings which would be necessary if the transitway tunnel was wide enough to accommodate both travel directions and the stations under one street. The proposed transitway descends as it goes north from Campus Station, under Laurier Avenue and continues under Daly Avenue through the Rideau Centre development, passing under the Rideau Canal and National Arts Centre and running under Albert and Slater Streets through the western portion of the Central Area until it exits through the escarpment west of Bronson Avenue and reaches the Lebreton Station at Booth Street. The tunnel portion is approximately 2.2 kilometres long, and with approaches of 0.8 km gives a project length of 3.0 km.

The twin tunnel transitway utilizes stations that join the twin tunnels by connecting them under the short block between Albert and Slater Streets. The stations consist of parallel loading platforms 110 m in length and up to 6.0 m wide. At the stations a passing lane is provided for maintaining service past a disabled vehicle. In the station area connecting the two platforms, space is provided for fare collection activities and a minor amount of space that can be used for passenger convenience retail activities. Each station is connected to the surface via stairs, escalators and an elevator. Street accesses to the stations are provided at four locations, or alternatively, some access can be provided through adjacent buildings depending upon the opportunities at each location. There are stations at Rideau Centre, and at three locations west of the Rideau Canal; at Metcalfe St., Bank St. and Lyon St. In establishing the preferred locations for stations, it was considered essential to have stations serving the Rideau Centre and Bank Street. Once

EXHIBIT A-1


N
WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
ALBERT
BRONSON
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
RIDEAU
WALLER
NICHOLAS
COLONEL
BY
RIDEAU
CANAL

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN

ALIGNMENT OF
THE RECOMMENDED
TWIN TUNNEL OPTION

those two locations were established, the remaining two station locations were a product of station spacing criteria and opportunities to serve the existing and proposed development.

The twin tunnel option provides superior operating conditions that generate significant operational savings for OC Transpo, time savings for passengers in addition to improved reliability and capacity of the Transitway through the Central Area. Also, benefits are realized by other street users due to the extra surface capacity provided by the removal of between 360 and 400 peak period Transitway buses from the surface streets. Using typical methods of estimating benefits associated with bus and vehicular surface operations, a positive return is indicated. When allowance is made for the costs of delays associated with the street level disruption during construction of either the cut and cover or elevated option, it becomes clear that the preferred overall option is the twin tunnel.

It is estimated that the twin tunnel Transitway can be built with a three to four year construction period using either a tunnel boring machine and/or drill and controlled blast technology with little disruption to the normal Central Area business, shopping and vehicular activities. Disruption would be limited to specific locations where access or ventilation points are located, and to the tunnel portals. This is in marked contrast to the significant physical disruption that would be caused over extended periods by either of the other two options.

The construction cost is a function of a number of important variables including a schedule for construction implementation and assumptions on the impact of inflation. The development of a financial plan and an implementation schedule were outside the scope of this study. Comparative cost estimates in $1988 were prepared for each of the final three options in enough detail so that the resulting estimates could be used in the comparative evaluation of the options.

The earliest date of operation, provided all approvals and funding are in place would be 1997. To meet that date, however, decisions have to be made now to fix the alignment and initiate the planning, engineering, costing and environmental and other special studies to firm up the details of the proposed project in the context of the ongoing development initiatives in the Central Area.

The recommended course of action will enable OC Transpo to maintain and strengthen its position as a dominant transport mode, particularly to the Central Area. This action plan is in keeping with the experience of other major cities that realize they have to place increasing reliance on public transit to overcome capacity deficiencies in key corridors, especially in and adjacent to the central area of the cities.

# STUDY TEAM

An international team of experts was assembled for this project. The firms are listed below together with their principals most directly involved.

| Firm | Principal | Discipline |
|---|---|---|
| Delcan Corporation, Ottawa | R. Wayne Bowes<br>C.M. Bishop<br>B. Friesen<br>R. Heinbuck<br>C. Martin<br>J. McGill<br>R. Kirkey<br>D. Hunt | Project Management, Structures, Utilities, Costing, Economic Analyses, Evaluation<br>Vehicle-Fuel Technology<br>Ventilation, Operations |
| Klohn Leonoff, Vancouver | M. Walia<br>Dr. R. Bensen | Tunnel Engineering |
| Toronto Transit Consultants, Limited Toronto | S. Lawrence<br>W. Bartram | Cut-Cover Option Investigations |
| Griffiths Rankin Cook, Ottawa | T. Griffiths<br>J. Swartz<br>R. Madunicky | Station Concepts<br>Urban Planning |
| Harry Weese & Assoc., Washington, D.C. | J. Corley | Station Concepts<br>Architectural Rendering<br>Urban Planning |
| J. Leaning & Assoc., Ottawa | J. Leaning | Urban Impact Analysis |
| Wilson Ihrig & Assoc., Oakland, Calif. | Dr. G. Wilson | Noise and Vibration Studies |
| H. Angus & Assoc., Toronto | G. Groza | Ventilation Studies |
| RWDI & Assoc., Guelph, Ontario | Dr. A. Davis | Fume/Ventilation Studies |
| J.C. Williams Consultants, Toronto | J.C. Williams<br>M. Atkinson | Urban Economic Analysis |
| A.H. Fitzsimmons & Assoc., Ottawa | A. Fitzsimmons | Urban Real Estate Impact |
| DSV International, Seattle, WA | J. Dow | Evaluation techniques,<br>Vehicle Technology,<br>Seattle Experience |
| G. Sauer Incorp., Vienna, Austria | Dr. G. Sauer | Tunnel Design |
| P. McCann & Assoc., Toronto | P. McCann | Cut-Cover Construction Techniques |
| Client Representatives | | |
| RMOC | I.G. Stacey | Director, Transitway Programme |
| | D.M. Beere | Project Manager |
| | V. Chi | Project Management Services Engineer |
| OC Transpo | J.A. Bonsall | General Manager |
| | Dr. H. Gault | Director, Systems Planning Division |

Technical Liaison Committee

| | |
|---|---|
| Mr. I.G. Stacey (Chairman) | Director, Transitway Programme |
| Mr. M.J.E. Sheflin | Transportation Commissioner, RMOC |
| Mr. J.A. Bonsall | General Manager, OC Transpo |
| Mr. A. Keklikian | National Capital Commission |
| Mr. T. Fletcher | Commissioner<br>Dept. of Planning & Development<br>City of Ottawa |
| Mr. R. Puccini | Exec. Director<br>Ministry of Transportation, Ontario (MTO) |
| Mr. A. Thompson | Project Manager<br>Ministry of Transportation, Ontario (MTO) |
| Mr. R. Hines | Environmental Planner<br>Ministry of Environment, Ontario (MTO) |

# CHAPTER 1

# 1.0 INTRODUCTION

## 1.1 Background

This report documents the findings of a study of the technical feasibility of grade separating the bus transitway through the Central Area over a distance of up to three kilometers connecting the existing transitway on the east and west sides. Currently the buses utilize surface bus lanes through the Central Area and operate in mixed traffic through a congested area that imposes significant delays and irregularities on the system during peak periods. In the p.m. peak, the 180-200 buses per hour on each of Albert and Slater Streets impose a burden on the roads and tax the capacity of the system.

The technical feasibility study examined three grade separated options: elevated, cut-cover, and tunnel, in sufficient detail to establish the feasibility of the options, to identify the operating characteristics of the transit system to accommodate bus and passenger volumes for the foreseeable development of the Central Area, to quantify the impacts of the options, and to identify a preferred option.

A multidisciplinary team was assembled to conduct the study. Summaries of the individual reports and technical findings of the various teams have been incorporated into this report. Each option is described briefly, evaluated and conclusions developed. A preferred option has been identified.

## 1.2 Public Transit in Ottawa-Carleton

The Ottawa-Carleton Regional Transit Commission (OC Transpo) has developed a strong regional transit system serving a dynamic National Capital Area. From the early 1970's when it was formed from the Ottawa Transit Commission with approximately 320 buses, to its current status with over 800 buses, OC Transpo has been an industry leader and pioneered many innovative measures designed to enhance the attractiveness of public transit and provide a high level of service that has been well received by its users.

Over the last 15 years, Regional Council's goals, sub-goals and intentions have been very important to the success of OC Transpo. The priorities assigned to transit have enabled OC Transpo to establish itself as an integral part of the total transportation network and a vital factor in the successful operation of the total transportation system throughout the Region. Without the passenger carrying ability of OC Transpo, especially to the Central Area and the corridors to the rapidly growing urban communities outside the greenbelt, the transport requirements to support the economic and social needs of the Region could not be met by the present system of roadways. Little opportunity exists to add significantly to the vehicular capacity of the major roadways feeding the Central Area.

### Operating Authority

Under Part IV-A of the Regional Municipality of Ottawa-Carleton Act, the Ottawa-Carleton Regional Transit Commission, or OC Transpo, was established by the Province of Ontario, as a body corporate with the exclusive right within the Regional Municipality of Ottawa-Carleton (RMOC) to maintain and operate a passenger transport service. Its board of directors (the Commission) comprises nine members of the Ottawa-Carleton Regional Council, including the Regional Chairman. OC Transpo has complete authority over its operations, including the setting of levels of service and fares. It is however subject to Regional Council's decisions with respect to the level of financial support to be provided from the property tax levy and for debenture requirements.

### Transitway Division

The Transitway Division of the Regional Municipality of Ottawa-Carleton is a section of the Transportation Department charged with the responsibility for the planning, design and construction of the Transitway system as approved by Regional Council. It is the agency that is responsible for the physical implementation of the Transitway system including the conduct of all studies related to Transitways. This study falls under the responsibility of the Director, Transitway Programme.

### 1.3 Transitway Programme

As public transit gained in popularity and in public acceptance in Ottawa-Carleton, passenger volumes grew and today the per capita ridership is the highest of any North American system serving a community of similar size. As this growth was occuring in the early and mid 1970's, the RMOC conducted several studies to identify the alignment and technology that should be utilized to accommodate the growing public use of the system. These studies recommended a corridor framework for bus rapid transit on its own right-of-way, and identified bus technology as being most appropriate for the proposed regional services. This bus rapid transit concept has been under construction since 1981 and its 1988 status is illustrated in **Exhibit 1.1.** Currently almost 20 kilometers of the Transitway are in operation, 3.5 km under construction and other sections are in various stages of planning or design.

A significant feature of the strategy employed in implementing this Transitway system, has been the decision to construct the outer portions first, and leave the more expensive Central Area section until the mid to late 1990's. This decision enabled the available funds to be used to construct a greater length of Transitway than may have been the case if the city centre portion was built first. This strategy enabled OC Transpo to greatly improve service levels for a large percentage of its customers and consolidated the status of the Transitway as a fundamental component of the regional transportation system, and thus established the transit system as an important influence on the land use development occurring in the Region.

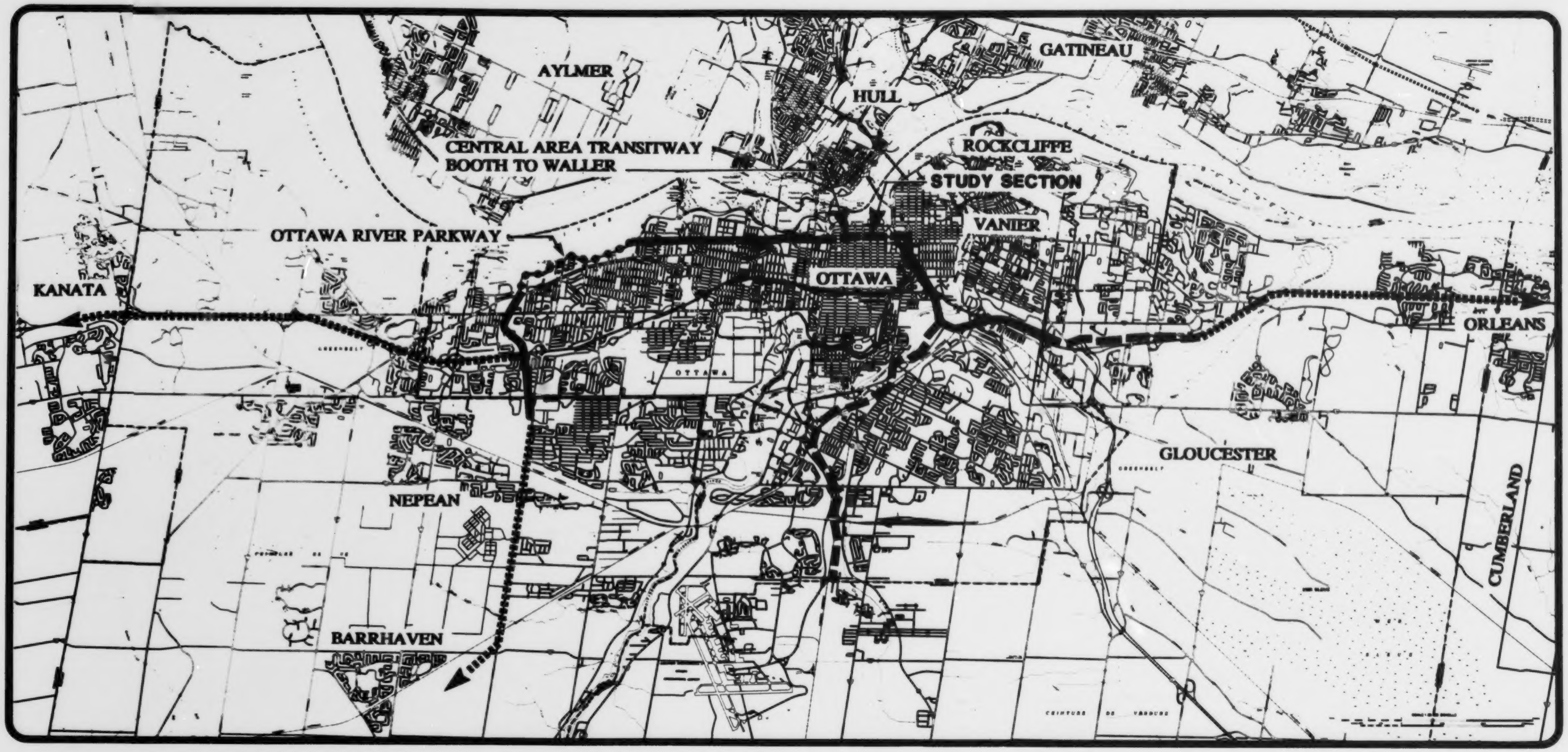
As expected in the original planning, as passenger volumes increased, the Central Area section, which operates on Albert and Slater Streets through the core of the city, began to experience difficulties due to the volume of peak hour buses (180 to 200 buses/hr. per direction), volume of passengers overflowing the limited sidewalk space at stops and the congested operating conditions on the streets which slow the buses down and cause a significant amount of variation and uncertainty in the scheduled times. These operational problems detracted from the transit service levels and were all the more noticeable as the core area operating conditions are very poor compared to the free running transitway sections outside the core. Passengers are making a fast trip in from the suburban areas, and then spending almost as long in the short downtown section.

In order to solve these problems prior to grade separation, the RMOC investigated alternative ways of improving the surface transit service through the Central Area. Early in 1987, the RMOC initiated a "surface options study" to review all surface concepts and define a preferred option for a surface transitway through the Central Area.

At the same time the Region set up a task force to identify ways of improving operations on Albert and Slater Streets in the short term. This resulted in the implementation of "fast acting lanes" in the summer of 1987. The curb lane was divided into a series of zones for stationary vehicle uses including bus loading, general traffic parking/loading and right-turn storage. The adjacent lane was dedicated as a bus only lane.

The "Surface Study" is to identify how the transitway bus volumes can be accommodated at current or better service levels, with acceptable impacts to downtown business, other street traffic, the transit system and its customers. The "Surface Study" will also provide guidance as to the length of time that the surface streets can continue to provide acceptable service levels to the growing volume of buses and passengers. When the surface streets can no longer handle the transit and traffic operation, grade-separation is the only answer.

EXHIBIT 1.1


AYLMER
GATINEAU
HULL
CENTRAL AREA TRANSITWAY
BOOTH TO WALLER
ROCKCLIFFE
STUDY SECTION
VANIER
OTTAWA RIVER PARKWAY
KANATA
OTTAWA
ORLEANS
GLOUCESTER
NEPEAN
CUMBERLAND
BARRHAVEN
GREENBELT
CEINTURE DE VERDURE

**LEGEND**

━━━━━━ IN OPERATION

━ ━ ━ ━ ━ IN PLANNING/DESIGN AND/OR CONSTRUCTION

┅┅┅┅┅┅ FUTURE EXTENSION

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN**

**TRANSITWAY**
**PROGRAMME**

## 1.4 Purpose for Study of Grade Separated Options

Recognizing that grade-separation will be eventually required, the RMOC commissioned this study with the purpose of investigating the technical feasibility of grade separated options connecting the existing Campus Station in the east to the existing transitway station in Lebreton Flats, with a view to recommending the best option for ultimate implementation. The study is to investigate both above and below grade options and is to be conceptual, i.e., not design, in nature. It is to consider all relevant factors such as noise, vibration and other environmental issues, urban impacts, operations, vehicle/fuel technology and the impact of implementation on the Central Area.

The study is organized into a three phase investigation. In Phase I, the various alternative alignments were identified and a preliminary assessment was made. The favoured options were further evaluated in Phase II and a preferred option for both above and below ground operation was identified. For the underground option, two variations were identified, one employing the use of tunnelling technology and the second incorporating the use of the cut-and-cover construction technique. In Phase III the preferred options were further refined, a single preferred option selected and documentation prepared. The intent of the study was to identify for RMOC the best alignment, its attributes and what the impacts may be both during and after construction.

## 1.5 The Corridor and Its Characteristics

### 1.5.1 General

The outline of the study area and the current zoning is shown in **Exhibit 1.2.** The area contains the major concentration of shopping, business, commerical and government offices, together with a high proportion of the employment in the Region. The Parliament Buildings form the northern boundary and Laurier Street the southern boundary.

Vehicular access from the south is provided on a number of streets, whereas access from the west is limited to the Ottawa River Parkway and Wellington Street, and the Albert/Slater pair. To the east, the Rideau Area Road Network, MacKenzie King Bridge and Laurier Avenue provide access.

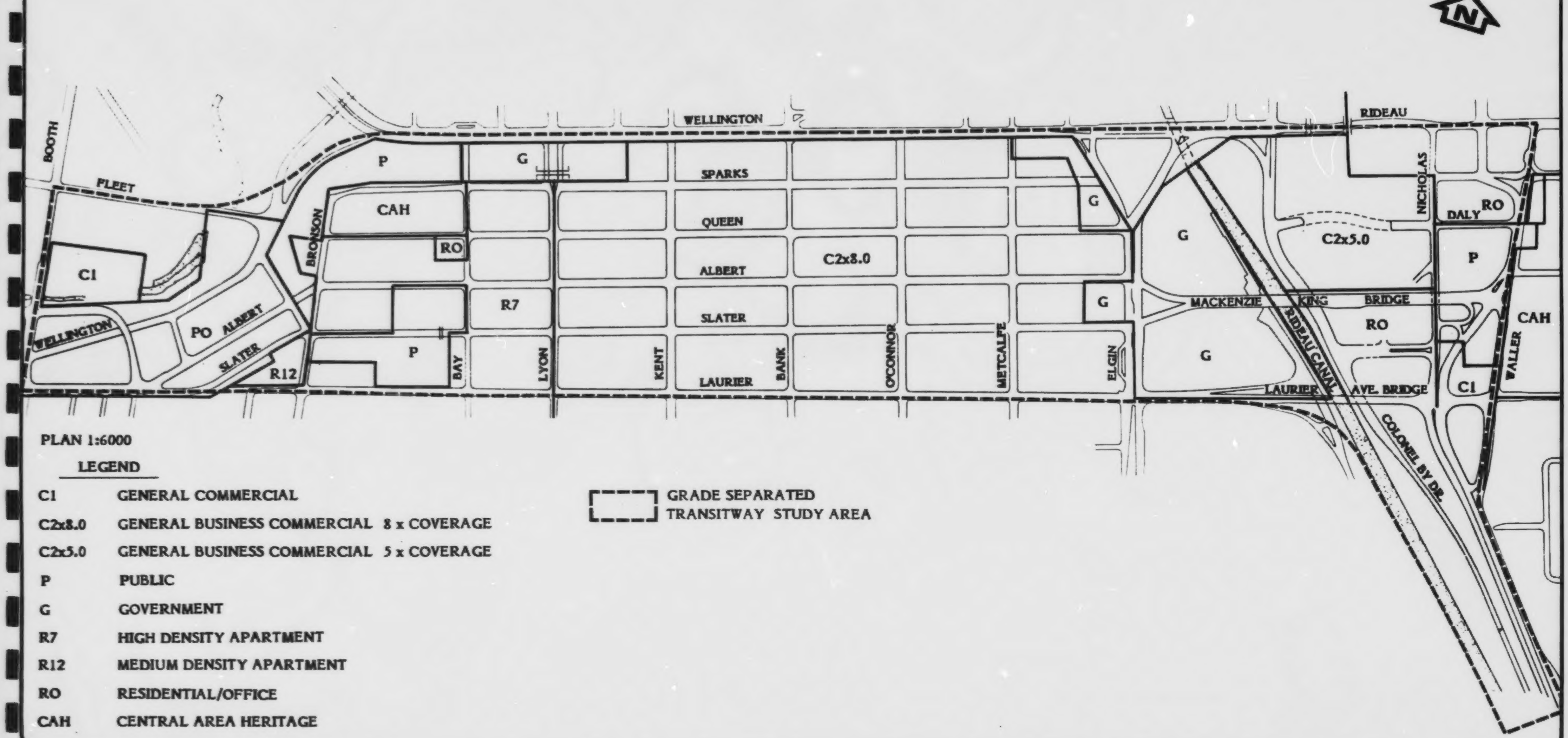
The bulk of the area west of Elgin Street to Lyon Street is zoned Central Business Commercial with 8 times coverage. West of this block to Bronson Avenue there is a mixture of high density residential and public land. Below the escarpment to the west, the zoning is residential/office with general commercial in the vicinity of Booth Street. Between Elgin and the Canal zoning provides for Government use. East of the Canal there is a large block of Central Business Commercial with 5 times coverage (including Rideau Centre) bounded by residential/office to the south encompassing the Department of National Defence building. There are general commerical zoning and public lands between the Transitway, Waller and Nicholas Street with Heritage zoning east of that.

In addition to the zoning controls, there are height limitations in each block which are shown on **Exhibit 1.3.** These numbers indicate height above sea level in metres. The height restrictions are designed to enhance and protect the Parliamentary Precinct. They limit the potential for future development to the north and favour high rise building with more open ground level space to the south.

This Exhibit also provides general information on the predominant uses that are planned for each section of the study area. The Core Area West is flanked to the west by highrise residential and to the north by Parliament. To the east a large public area lies between the Core Area West and Core Area East. Thus the transitway corridor will traverse the entire Core Area West and East and will be in a powerful position of tying these areas together.

**Exhibit 1.4** presents information on various aspects of the Central Area. The key views are identified. There are a number of sites that hold significant

**EXHIBIT 1.2**


N
BOOTH
FLEET
WELLINGTON
RIDEAU
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
BRONSON
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
NICHOLAS
DALY
WALLER
MACKENZIE KING BRIDGE
LAURIER AVE. BRIDGE
RIDEAU CANAL
COLONEL BY DR.
P
G
CAH
RO
C1
C2x8.0
C2x5.0
R7
R12
PO
PLAN 1:6000

LEGEND

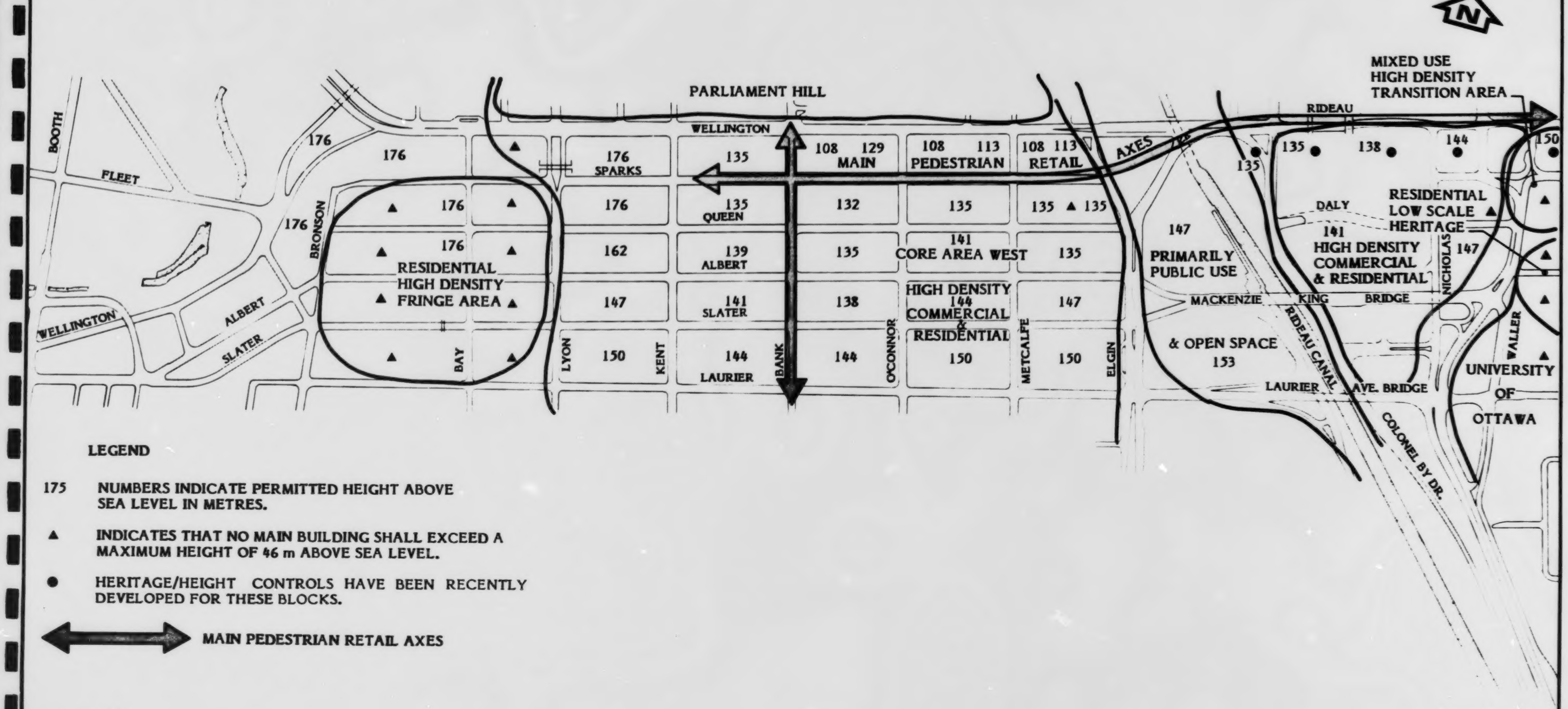
| | |
|---|---|
| C1 | GENERAL COMMERCIAL |
| C2x8.0 | GENERAL BUSINESS COMMERCIAL 8 x COVERAGE |
| C2x5.0 | GENERAL BUSINESS COMMERCIAL 5 x COVERAGE |
| P | PUBLIC |
| G | GOVERNMENT |
| R7 | HIGH DENSITY APARTMENT |
| R12 | MEDIUM DENSITY APARTMENT |
| RO | RESIDENTIAL/OFFICE |
| CAH | CENTRAL AREA HERITAGE |

┌ ─ ┐ GRADE SEPARATED TRANSITWAY STUDY AREA

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / GRIFFITHS, RANKIN & COOK

## STUDY AREA AND ZONING

**EXHIBIT 1.3**


N
PARLIAMENT HILL
MIXED USE
HIGH DENSITY
TRANSITION AREA
RIDEAU
WELLINGTON
BOOTH
FLEET
176
176
176
176
176
176
176
BRONSON
RESIDENTIAL
HIGH DENSITY
FRINGE AREA
BAY
ALBERT
SLATER
WELLINGTON
SPARKS
162
147
150
LYON
KENT
135
135
QUEEN
139
ALBERT
141
SLATER
144
LAURIER
BANK
108 129
MAIN
132
135
138
144
O'CONNOR
108 113
PEDESTRIAN
135
141
CORE AREA WEST
HIGH DENSITY
144
COMMERCIAL
&
RESIDENTIAL
150
METCALFE
108 113
RETAIL
AXES
135
135
135
147
150
ELGIN
147
PRIMARILY
PUBLIC USE
& OPEN SPACE
153
MACKENZIE
KING
BRIDGE
RIDEAU CANAL
LAURIER
AVE. BRIDGE
COLONEL BY DR.
135
135
138
144
150
DALY
RESIDENTIAL
LOW SCALE
HERITAGE
141
HIGH DENSITY
COMMERCIAL
& RESIDENTIAL
147
NICHOLAS
WALLER
UNIVERSITY
OF
OTTAWA

LEGEND

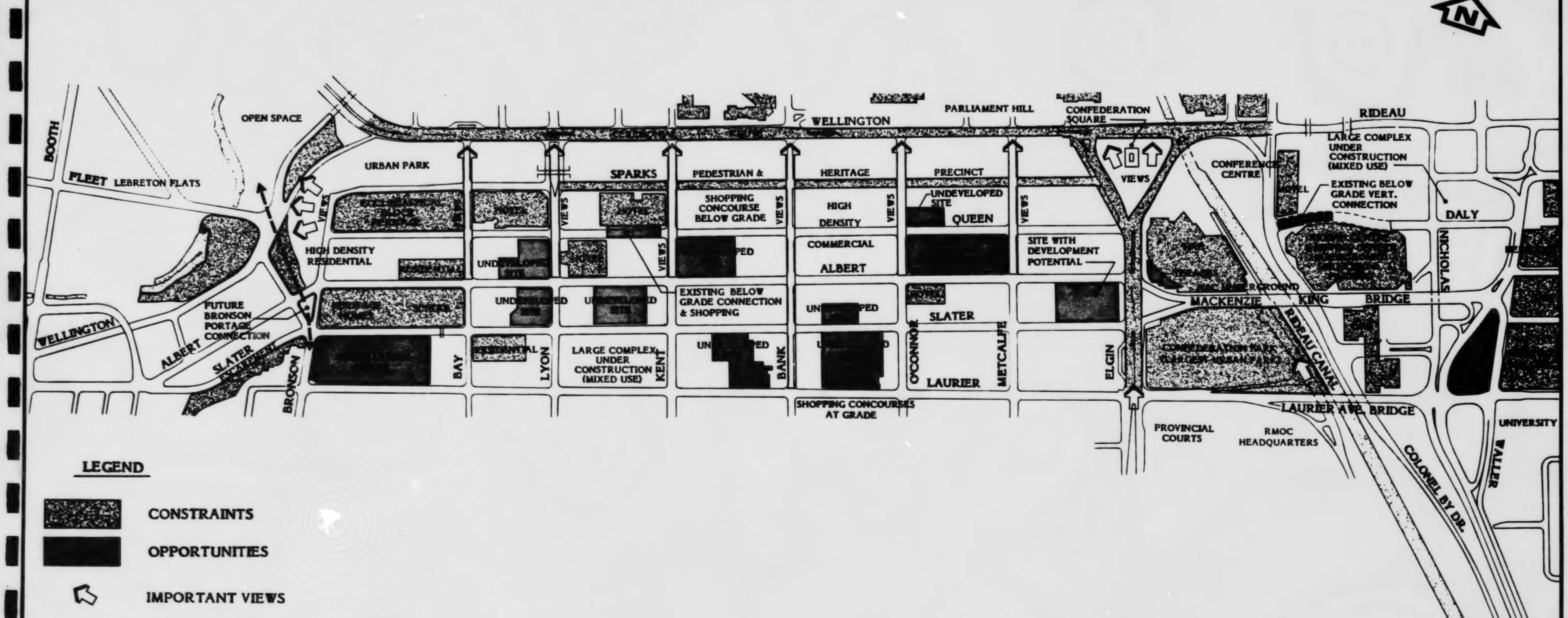
| | |
|---|---|
| 175 | NUMBERS INDICATE PERMITTED HEIGHT ABOVE SEA LEVEL IN METRES. |
| ▲ | INDICATES THAT NO MAIN BUILDING SHALL EXCEED A MAXIMUM HEIGHT OF 46 m ABOVE SEA LEVEL. |
| ● | HERITAGE/HEIGHT CONTROLS HAVE BEEN RECENTLY DEVELOPED FOR THESE BLOCKS. |
| ⟷ | MAIN PEDESTRIAN RETAIL AXES |

PLAN 1:6000

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN /GRIFFITHS, RANKIN & COOK

## CENTRAL AREA
## BUILDING HEIGHTS
## AND POLICY FRAMEWORK

**EXHIBIT 1.4**


N
BOOTH
FLEET
LEBRETON FLATS
OPEN SPACE
URBAN PARK
WELLINGTON
PARLIAMENT HILL
CONFEDERATION SQUARE
RIDEAU
SPARKS
PEDESTRIAN &
HERITAGE
PRECINCT
VIEWS
SHOPPING CONCOURSE BELOW GRADE
HIGH DENSITY
COMMERCIAL
UNDEVELOPED SITE
QUEEN
ALBERT
HIGH DENSITY RESIDENTIAL
RESIDENTIAL
SITE WITH DEVELOPMENT POTENTIAL
EXISTING BELOW GRADE CONNECTION & SHOPPING
UNDEVELOPED
UNDEVELOPED SITE
FUTURE BRONSON PORTAGE CONNECTION
SLATER
SLATER ESCARPMENT
LARGE COMPLEX UNDER CONSTRUCTION (MIXED USE)
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
BRONSON
LAURIER
SHOPPING CONCOURSES AT GRADE
CONFERENCE CENTRE
HOTEL
LARGE COMPLEX UNDER CONSTRUCTION (MIXED USE)
EXISTING BELOW GRADE VERT. CONNECTION
DALY
NICHOLAS
MACKENZIE KING BRIDGE
CONFEDERATION PARK
RIDEAU CANAL
LAURIER AVE. BRIDGE
PROVINCIAL COURTS
RMOC HEADQUARTERS
COLONEL BY DR.
UNIVERSITY
WALLER
LEGEND
CONSTRAINTS
OPPORTUNITIES
IMPORTANT VIEWS

PLAN 1:6000

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / GRIFFITHS, RANKIN & COOK

**CONSTRAINTS AND OPPORTUNITIES**

redevelopment potential. Locations of Heritage facilities are also shown. These constraints limit the potential of developing a transitway corridor without adverse impact. The constraint areas are generally at the western and eastern ends of the corridor, whereas the opportunities for redevelopment are generally scattered through the Central Area between Elgin Street and Bronson Avenue.

In general, the study area is a very sensitive and important area. It contains some heritage facilities including very important, nationally significant views of the Parliamentary Precinct. The core of the regional business and commerical facilities is located in the area between Bronson and Elgin, north of Slater Street. The extensive pedestrian mall along Sparks Street as well as one of the Region's largest shopping malls (Rideau Centre), are located in the Study area. The Confederation Boulevard (Wellington, Elgin) is also in the immediate Study area. All of these facilities have the potential to be affected, either positively or negatively, by a grade separated transitway.

The east-west street system in the area is characterized by narrow (18 m) street widths. This has resulted in narrow sidewalks where buildings are constructed to the property line. Recent policies have been somewhat successful in developing a setback of buildings from the street line to enhance the sidewalk width. Narrow street widths contribute to more congested sidewalks, more congested utility plant under the streets, and less opportunity to develop the Transitway facility entirely within the available right-of-way, especially at stations.

A detailed review of the Study Area was carried out by John Leaning and Associates, and Griffiths Rankin Cook, Architects, with the objective of identifying all the major physical features that must be recognized in the planning stages. Photo montages of various views were prepared to assist in developing an appreciation of the impact on the views and vistas. This review provided important information for the evaluation of the options.

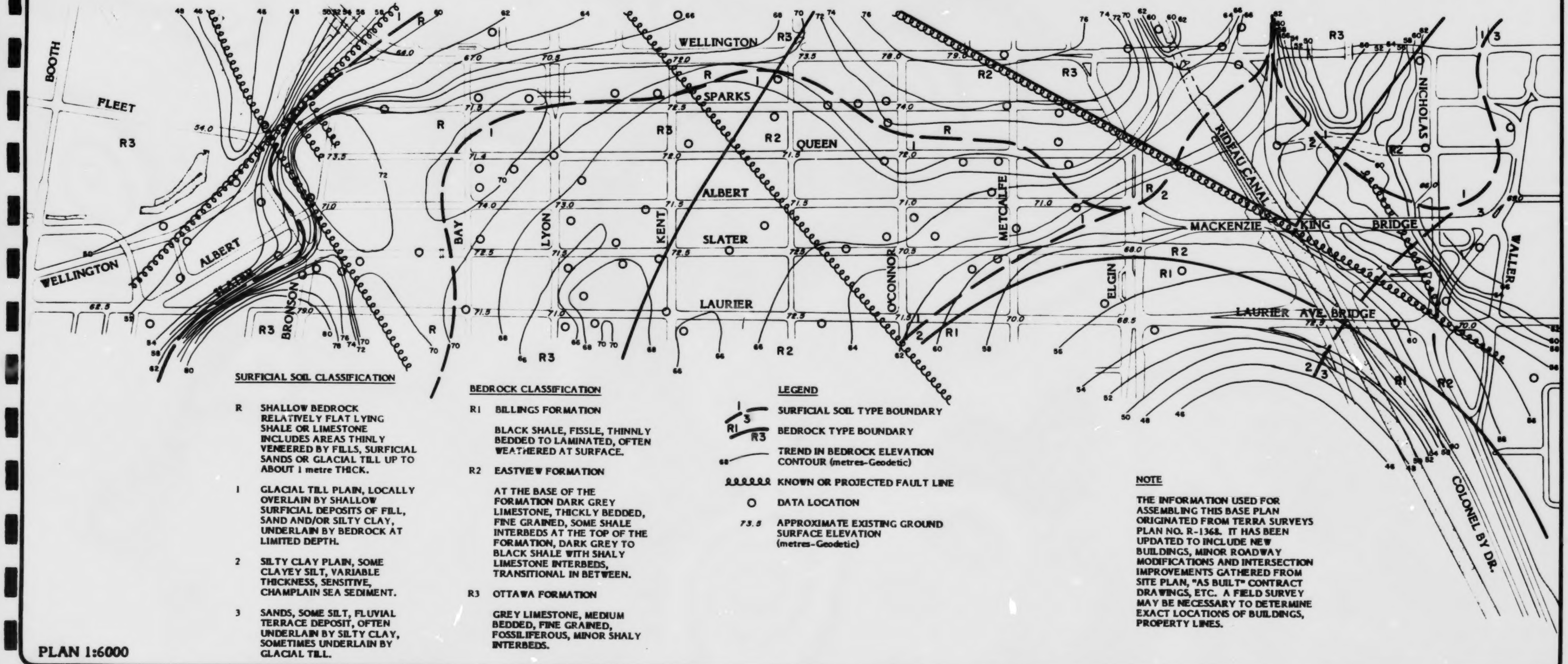
### 1.5.2 Geology of Study Area

The geology of the study area is of prime importance to both underground options. Existing information on subsurface conditions in the study area was collected from various sources. The data was collected, collated and plotted on a geotechnical planning map which is shown as **Exhibit 1.5.** On this Exhibit the various surficial soil types are given, the bedrock formations are shown, the contours of the bedrock surface are given at 2 metre intervals, and the presence of major bedrock features such as faults are shown. The specific test hole locations are shown on this plan where such data were available.

The information given on this exhibit must be considered as approximate only since the existing data are widely spaced in some areas and interpolation was required. An intensive geological study will be required to complete the knowledge of the subsurface conditions before undertaking further work on an underground option.

The general conclusion of the review of the geology was that it would be an ideal structure for tunnelling.

**EXHIBIT 1.5**


N
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ALBERT
SLATER
LAURIER
O'CONNOR
METCALFE
ELGIN
RIDEAU CANAL
MACKENZIE KING BRIDGE
LAURIER AVE. BRIDGE
NICHOLAS
WALLER
COLONEL BY DR.
R
R1
R2
R3
1
2
3
73.5
72.0
71.5
71.0
74.0
70.5
70.0
68.5
68.0
54.0
62.5

SURFICIAL SOIL CLASSIFICATION

- R SHALLOW BEDROCK RELATIVELY FLAT LYING SHALE OR LIMESTONE INCLUDES AREAS THINLY VENEERED BY FILLS, SURFICIAL SANDS OR GLACIAL TILL UP TO ABOUT 1 metre THICK.
- 1 GLACIAL TILL PLAIN, LOCALLY OVERLAIN BY SHALLOW SURFICIAL DEPOSITS OF FILL, SAND AND/OR SILTY CLAY, UNDERLAIN BY BEDROCK AT LIMITED DEPTH.
- 2 SILTY CLAY PLAIN, SOME CLAYEY SILT, VARIABLE THICKNESS, SENSITIVE, CHAMPLAIN SEA SEDIMENT.
- 3 SANDS, SOME SILT, FLUVIAL TERRACE DEPOSIT, OFTEN UNDERLAIN BY SILTY CLAY, SOMETIMES UNDERLAIN BY GLACIAL TILL.

BEDROCK CLASSIFICATION

- R1 BILLINGS FORMATION

  BLACK SHALE, FISSLE, THINNLY BEDDED TO LAMINATED, OFTEN WEATHERED AT SURFACE.
- R2 EASTVIEW FORMATION

  AT THE BASE OF THE FORMATION DARK GREY LIMESTONE, THICKLY BEDDED, FINE GRAINED, SOME SHALE INTERBEDS AT THE TOP OF THE FORMATION, DARK GREY TO BLACK SHALE WITH SHALY LIMESTONE INTERBEDS, TRANSITIONAL IN BETWEEN.
- R3 OTTAWA FORMATION

  GREY LIMESTONE, MEDIUM BEDDED, FINE GRAINED, FOSSILIFEROUS, MINOR SHALY INTERBEDS.

LEGEND

| | |
|---|---|
| 1 / 3 | SURFICIAL SOIL TYPE BOUNDARY |
| R1 / R3 | BEDROCK TYPE BOUNDARY |
| 68 — | TREND IN BEDROCK ELEVATION CONTOUR (metres-Geodetic) |
| ℓℓℓℓℓ | KNOWN OR PROJECTED FAULT LINE |
| ○ | DATA LOCATION |
| 73.5 | APPROXIMATE EXISTING GROUND SURFACE ELEVATION (metres-Geodetic) |

NOTE

THE INFORMATION USED FOR ASSEMBLING THIS BASE PLAN ORIGINATED FROM TERRA SURVEYS PLAN NO. R-1368. IT HAS BEEN UPDATED TO INCLUDE NEW BUILDINGS, MINOR ROADWAY MODIFICATIONS AND INTERSECTION IMPROVEMENTS GATHERED FROM SITE PLAN, "AS BUILT" CONTRACT DRAWINGS, ETC. A FIELD SURVEY MAY BE NECESSARY TO DETERMINE EXACT LOCATIONS OF BUILDINGS, PROPERTY LINES.

PLAN 1:6000

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / GOLDER ASSOCIATES

## GEOTECHNICAL PLANNING MAP

# CHAPTER 2

# 2.0 NEED FOR A SOLUTION

## 2.1 Introduction

The current transitway service operates from Baseline Station, along the Southwest and West Transitways to Albert and Slater Street through the Central Area, across the MacKenzie King Bridge along Waller Street and along the Southeast and East Transitways to the St. Laurent Station. Through the length of the Central Area, the transitway bus services, approximately 180-200 buses in each direction in the peak hour, operate on a bus lane in mixed traffic eastbound on Slater and westbound on Albert Street. Each of these streets has 4 lanes and they operate as a pair of one way streets providing access to properties as well as through traffic functions. The combination of this volume of buses and up to 9000 boarding passengers in the peak hour exceeds that of any other surface transit operation in North America.

The buses operate with-flow, on an exclusive lane, one lane out from the curb lane. The curb lane is not a through lane and is generaly divided into two uses, separated by a sidewalk bulb at mid-block. Sections are used to provide stopping areas for buses, for deliveries, taxis, right turn lanes, etc. Two lanes are left for general traffic during peak periods. In off-peak periods, parking is allowed in the other curb lane.

Traffic volumes are heavy, as one might expect, through the downtown on both the north-south and east-west streets. The north-south blocks are relatively short, 60 m, and do not have much storage capacity. This contributes to a tendency for the traffic to block the east-west street intersections.

The interim traffic and transit improvement measures, "fast acting lanes", currently in place provide a marginally acceptable level of transit service at today's volume but there is little or no spare capacity to accommodate future growth and minor disruptions to the general traffic flow quickly produce a total breakdown in transit which in turn affects service to all parts of the Urban Transit Area. Typical indicators of this lack of capacity are the following:

- insufficient space at the bus stops for the passenger queues in the peak periods and therefore, no room for other pedestrians trying to use the street;
- insufficient space at the bus stops for more than 3 buses, with the result that buses often stack up and extend into the bus lane;
- poor passenger loading discipline in that buses may have to stop twice in a loading zone for passengers, and passengers prefer to use only the front door of the articulated buses;
- vulnerability of the transit system to delays caused by road accidents and loading activities and insufficient spare capacity to permit recovery;
- general traffic disruption due to volume, missed traffic light sequences, etc.

With the continued growth of employment and other activity in the Central Area and the Region generally, vehicular and bus traffic will continue to increase. Transit currently has a high modal split during peak periods, estimated to be in the 70 percent range for downtown work trips. Although transit has some room to claim more market share, it will not be a significantly larger share, and thus transit volumes and auto volumes will continue to grow as the employment in the Central Area increases from 70000± to 95000± between now and 2001.

The most likely scenario for the future if nothing is done to remove Transitway traffic from the surface will be along the following lines:

- The Central Area will continue to be the focus for major office and commercial activity for the Region, as well as a significant destination for shopping, recreation and other trips. This development will lead to a continued growth in travel demands to, from, and within the Central Area by bus, pedestrian and auto. Service truck traffic, characterized by delivery, courier and other small to medium sized trucks will also continue to grow.

- The traffic volumes will increasingly tax the street capacity. Relief may be offered in some degree by other major roadway projects that could divert some of the through traffic that is currently in the Central Area. These improvements include traffic signal management, and the proposed Bronson-Portage connection. However, on Albert/Slater, the effects of these improvements may be minor. This is because the east-west capacity in the Central Area may be further affected by plans for the implementation of a Confederation Boulevard on Wellington. Queen Street is already performing a service and access function with little ability to add significantly to capacity. It already accommodates some transit routes.

  Conditions on Albert and Slater are not expected to improve materially for buses. Recognizing the variations in traffic flow, intersection blockages, pedestrian interference and bus loading requirements and the operation of all articulated buses, the practical capacity will be, in all likelihood, in the range of 180 to 200 buses per hour, not significantly different from today. Any increase above these levels may be at the cost of an additional bus lane at intersections with consequent reduction in the general traffic capacity.

- Traffic congestion will then start to move marginally into the shoulder areas of the peak, thus spreading the peak period and extending the period of congested operation in the Central Area.

- Bus volumes will not significantly increase on Albert/Slater while the substitution of articulated vehicles for standard vehicles occurs. However, loading time may increase and schedule reliability decrease to the point where the attractiveness of the service may affect peoples' decisions to use the buses for travel to the Central Area. Because roads are also congested and parking is costly, the Central Area begins to lose its appeal and desirability as an employment node in favour of other less congested areas. This will affect the role of the Central Area in the long term. It will also reduce the transit level of service to all the other developing nodes along the transitway from Kanata to Orleans and Baseline to South Keys.

- Eventually, a point will be reached when it will be very difficult to accommodate travel to, from and within the Central Area. Many employers who do not absolutely have to be in the area could relocate, leaving the Central Area to evolve into a typical "head-office" oriented area. Unfortunately this type of development does little for "life" in the Central Area after working hours.

- Because of the reduced level of service for all Transitway service, the attractiveness of the development nodes at key stations would diminish and the assumptions on which the road requirements of the Official Plan are based would not be achieved.

- During this extended period of congestion, the cost of surface operation would become onerous for OC Transpo, on the transit passengers and would affect all other street traffic also. Costs of operating at slow speeds (as compared to the grade separated transitway) can amount to several million dollars per year, and when the time costs associated with the passengers are accounted for, the costs of congestion mount up quickly.

- There is a physical limitation on the number of buses that can be accommodated on Albert/Slater. As the demand grows other streets namely Queen or Laurier may have to be used for bus routes, with peak period priority measures to accommodate the traffic. This will affect the general street traffic.

- Unless significant improvements can be made by this point in time, transit ridership to the CBD will stablize or decline and the potential benefits of the investment already made in the Transitway will never be realized.

The above scenario is constructed as a possible development given no significant change from the status quo. Obviously conditions will not be permitted to degenerate to a standstill as pre-emptive decisions will be taken before this situation could develop. However, for the purposes of a comparison with a true base case, "do nothing", scenario, it is important at least to hypothesize the characteristics of this possibility. What is very clear is that there is a physical limit to the transit capacity that can be provided on Albert/Slater Streets given the need to protect service levels, and provide capacity for other street users. The demand for travel will exceed this capacity in the short-term, and provisions to accommodate this excess demand will have to be made in order to avoid deterioration in service levels to all street users. In this respect Ottawa-Carleton is no different from many other growing North American municipalities which eventually reach a point where their existing transportation system can no longer accommodate the traffic generated by their downtown areas. The solutions are either no more central area employment growth, more roads or a new right-of-way for public transit.

Parallel to this study of grade separated options, the RMOC is conducting a "surface facilities" study whose objective is to identify measures that can be taken along Albert and Slater Streets to protect and enhance the ability of the streets to accommodate the transit volumes and other street traffic as well. Extensive traffic management schemes are being tested. Close cooperation between the study team, the local businesses and OC Transpo is part of the study design. It is anticipated that a mutually acceptable scheme will be developed that will enable Albert and Slater Streets to provide an acceptable level of service to all users until a grade separated option can be implemented.

## 2.2 Transit Passenger and Vehicular Volumes

### 2.2.1 Current Passenger Volumes

OC Transpo operates a fleet of over 800 transit vehicles and provides transit service to over 81 million riders annually. On a typical winter day up to 350,000 riders use the system, and over 200 000 of these do so during the two peak periods.

Currently (1987/88) the transit passenger volumes in the p.m. peak hour, on the Transitway exiting the Central Area to the east and west total approximately 13 000 passengers. This volume is lower (approximately 15%) than the corresponding a.m. peak hour volumes. The actual peak load points of the system are east and west of the Central Area and currently a.m. peak hour volumes are 9000 passengers/hour. However, for planning purposes, the p.m. peak hour downtown volume is the critical volume as it influences the station platform design. The a.m. peak hour volume influences the design of the station exiting capacity via stairs and escalators. This volume of travel is accommodated on approximately 180-200 buses in each direction. A mixed fleet of articulated and standard buses provides this service. Passengers board at Campus Station, Laurier St., MacKenzie King Bridge, four stops between Elgin and Bronson, and at Lebreton Station (Booth Street). Bank Street is the busiest station with approximately 1600± passengers boarding per direction in the p.m. peak hour.

### 2.2.2 Future Passenger Volumes

The RMOC has recently completed an update to its Official Plan. In that planning exercise, various transportation planning model tests were conducted to develop estimates of likely future travel volumes by corridor. As a result of that exercise, estimates were developed for travel out of the Central Area, including transit trips which would be on the Transitway. Other transit trips out of the Central Area will continue to be made on other routes and streets. The following Table 2.1 summarizes the travel volume forecasts.

TABLE 2.1

TRAVEL OUT OF CENTRAL AREA
P.M. PEAK HOUR

| Year | Person Trips | Modal Split | All Transit Trips | Non-Transit Trips | Two Way Trips on the Transitway |
|---|---|---|---|---|---|
| 1988 | 40 500 | 54% | 22 000 | 18 500 | 13 000 |
| 2001 | 48 500 | 60% | 29 000 | 19 500 | 19 000 |
| 2014 | 55 500 | 65% | 36 000 | 19 500 | 25 000 |

This work on future transit volumes was coordinated with OC Transpo who was able to conduct more detailed analyses using the EMME/2 planning model.

The 2001 timeframe coincides with the Regional Official Plan population estimate of approximately 725 000 in the RMOC and 90 000 to 95 000 employees in the Central Area. The 2014 timeframe is a long term future estimate used to provide a transit passenger volume estimate that any new facility should be able to accommodate. This will allow for future flexibility and additional growth beyond what is contemplated for the

Central Area at the present time. It should be noted that these future year volumes include some of the present Queen Street transit services.

A number of factors will have a strong influence on whether and when the future transit passenger volumes will be realized and how they would be accommodated. Among these factors are the following:

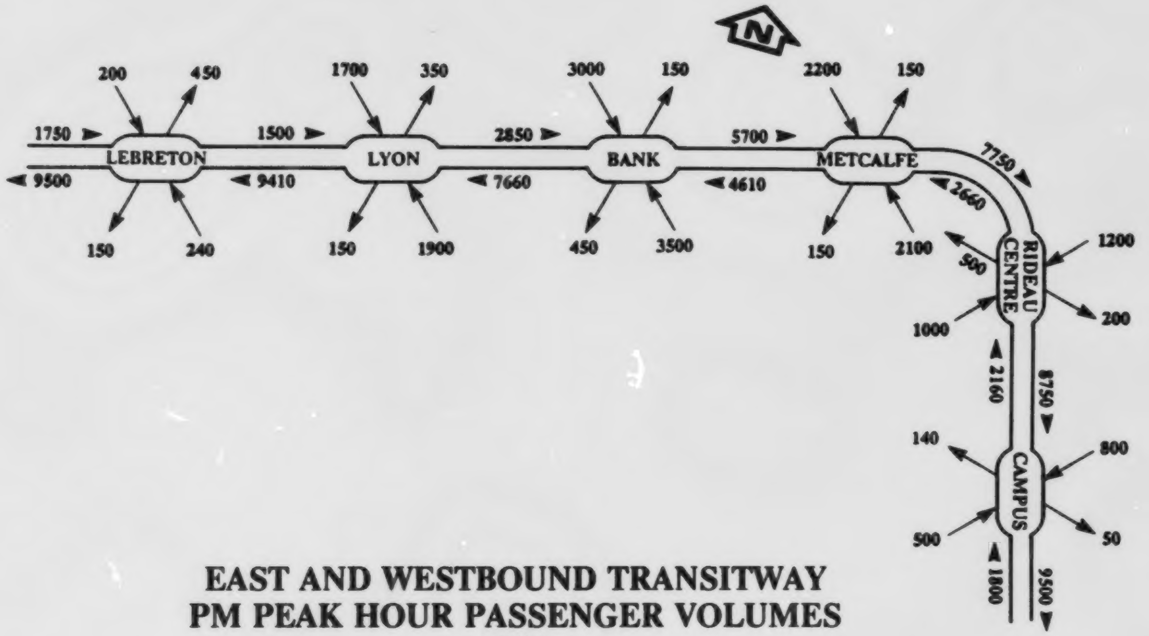
- employment growth in Central Area beyond the currently planned levels;
- employment growth at other nodes of the Transitway;
- employment growth at non-Transitway nodes;
- future development of the Transitway;
- volume of through trips;
- service levels for transit (seating, speed, etc.);
- ability of the roadway system to accommodate an increasing share of the total traffic; and
- relocation of the Queen Street services.

The future Transitway volumes have been analyzed by direction through the Central Area, and the on-offs estimated for the future Transitway station locations. For the purposes of this analysis, the volumes in p.m. peak hour were split equally east and westbound. There are six stations in the analysis area:

- Campus Station (existing)
- Rideau Centre
- Metcalfe
- Bank
- Lyon
- LeBreton.

The following **Exhibit 2.1** presents the on- and off-line volumes for the p.m. peak hour for 2001 Transitway volume, and also presents the same data for the 2014 planning horizon. The Central Area streets will continue to be very

## EXHIBIT 2.1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CAMPUS
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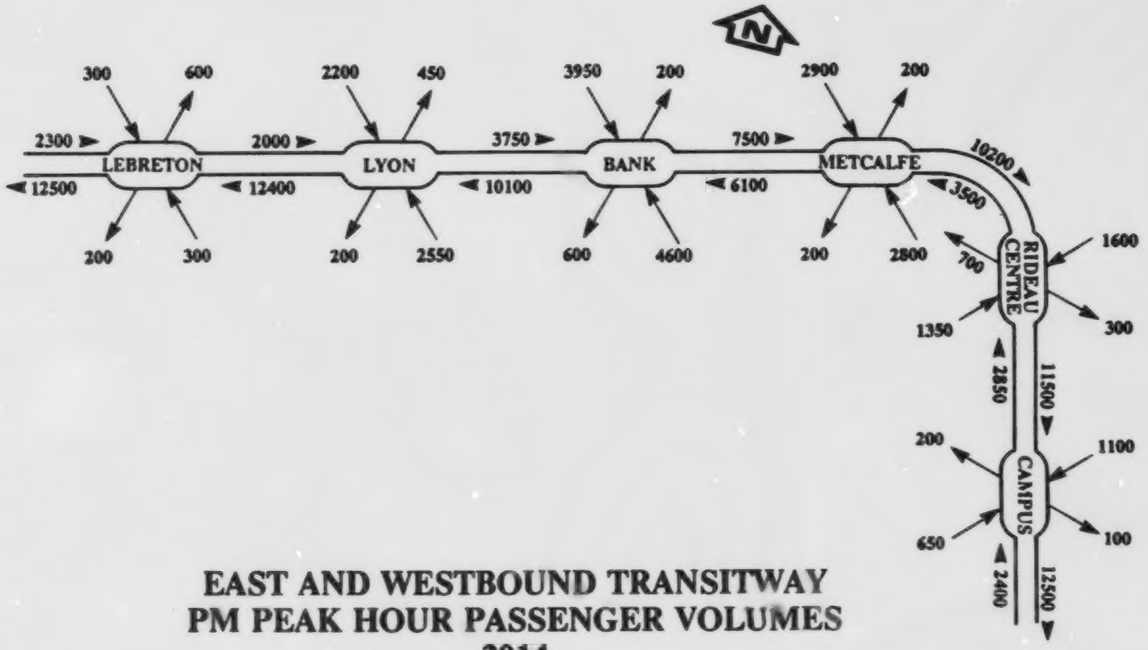
EAST AND WESTBOUND TRANSITWAY
PM PEAK HOUR PASSENGER VOLUMES
2001
(AT RMOC POPULATION OF 745,000)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1100
CAMPUS
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100
2400
12500

EAST AND WESTBOUND TRANSITWAY
PM PEAK HOUR PASSENGER VOLUMES
2014

## P.M. PEAK HOUR
## TRANSIT
## PASSENGER VOLUMES
## 2001/2014

busy facilities. A Transitway solution that frees up Central Area street capacity will have a beneficial impact on the remaining street traffic.

## 2.3 Service Levels

OC Transpo enjoys one of the highest ridership levels of all North American transit systems which may be surprising to some since Ottawa-Carleton does not have a heavy rail system. Ridership levels on an annual revenue rides per capita basis are significantly higher than in comparable Canadian cities like Edmonton, Calgary, Winnipeg and Vancouver. This ridership level is broadbased and is a result of offering an attractive service to customers.

What are the factors that the customer values highly? In general, the customer has been responding to several factors. Some of these have been positive, i.e., attractive service levels, and some have been negative factors such as road congestion, cost of travel by auto, cost and supply of parking spaces.

The transit service factors that are commonly associated with an attractive service level are:

- frequency of service
- comfortable load factor (availability of seats)
- directness of travel
- travel time
- need for transfer

These attributes of good service levels are the ones that are, or will be, affected by continuing surface operation through the Central Area. To protect these service levels, and in fact enhance them over the next 20 years or so, will be an important challenge that must be met successfully if OC Transpo is to attract the ridership levels estimated. Failure to achieve high service levels will, if experience elsewhere is a guide, lead to an increase in automobile travel. This will lead to increasing congestion in the Central Area and deterioration to overall lower service levels for all traffic. This could precipitate an accelerated shift of employment to more dispersed locations where transit may not be able to offer a competitive service level. There would be a demand for the construction of more roads to serve the employment shift.

### 2.3.1 Frequency of Service and Load Factor

Currently, approximately 180 buses (standard and articulated) per hour per direction in the p.m. peak hour provide services through the Central Area. These buses are assigned to routes with various frequencies from 4 minutes to 20 minutes. As the number of articulated buses is increased and the number of standard buses decreased, additional capacity can be provided and the overall frequency preserved.

Customers are sensitive to frequency for it determines how long they have to wait. Currently, the p.m. peak hour exiting volume for each of eastbound and westbound directions is approximately 6 500 passengers, on 180 buses (150 std, 30 artic.). Load factor is approximately 0.7. The remaining capacity is required to serve boarding passengers outside the downtown.

It is planned that the substitution of articulated buses for standard buses can be made at a rate that maintains the same frequency and load factor while increasing capacity to accommodate 9 500 passengers by 2001, and 12 500 passengers by 2014, in each direction out of the Central Area. This is shown in Table 2.2.

The articulated bus seating capacity will vary according to the floor plan selected, and may range up to 64 seats. A configuration with 58 seats is used in this analysis. This seating arrangement provides good aisle space and space at the three large door sets. For purposes of this analysis, it has been assumed that a comfortable load on an articulated bus could be 70, which then indicates 12 standees. This is a compromise on the fully seated load as a standard for measuring load factor and introduces some discontinuities in the service level discussions. However, it represents a recognition that at higher

### TABLE 2.2

### TRANSIT PASSENGER VOLUME AND ESTIMATED LOAD FACTOR

| Year | Passenger Volume 2 Way P.M. Peak Hour | No. of Bus Trips (2 Way) STD. | No. of Bus Trips (2 Way) ARTIC. | Bus Capacity (2 Way) | Load Factor Exiting Central Area |
|---|---|---|---|---|---|
| 1987 | 13 000 | 300 | 60 | 19 200 | 0.68 |
| 1995 | 16 000 | - | 360 | 25 200 | 0.63* |
| 2001 | 19 000 | - | 360 | 25 200 | 0.75 |
| 2014 | 25 000 | - | 474 | 33 180 | 0.75 |

* Tied to the rate of substitution of articulated buses, and maintaining frequency.

volumes and increased pressure of peak hour flows, it would be desirable for OC Transpo to rationalize service levels so that costs of operation and capital expenditure are reduced.

The 0.75 average Load Factor target exiting the Central Area recognizes that the buses must have some capacity to pick up passengers at stations immediately east and west of the Central Area and accommodate surges within the peak. Thus the line load factor will increase outside of the Central Area.

### 2.3.2 Directness of Travel

Directness of travel is associated with both the suburban pickup and drop-off portion of the trip, and the destination routing in the Central Area. The suburban routes are designed to provide good coverage and must, of necessity, involve some circuitous travel in order to service the appropriate pickup area. The suburban routing however should avoid any back haul as it is not generaly acceptable to the passengers.

The bus route should also provide as direct a route as possible to the heart of the employment area. In the Central Area, there are a limited number of east-west streets that are available for good coverage, and all streets are subject to increasing congestion as travel volumes, both auto and pedestrian, increase. It will be important to provide a grade separated alignment that achieves good Central Area coverage of the employment and business/commercial areas. Currently Albert and Slater Streets provide excellent coverage in this regard. Future plans for Central Area growth indicate that these streets will continue to provide good coverage. The alignment should also be well located with respect to the remaining surface routes in the Central Area, and thus avoid or minimize passenger inconvenience in transferring.

### 2.3.3 Travel Time

Travel time is a key service level factor that frequently precipitates the need for transportation improvements. If travel time was not an important factor then there would be little reason to provide facilities that reduce congestion. People could sit in their buses or autos while moving slowly to their destination or travel outside the peak periods. However, society places a value on time and promptness, thus it is important to provide a free flowing facility to achieve appropriate service levels. In the case of transit, this requirement is two fold, acceptable travel time and predictable operations or schedule.

Travel speeds achievable on the Transitway match or exceed those available to the general traffic on parallel arterials, with the result that over the last few years, as portions of the Transitway came into operation, travel time has been improving for travel from the suburbs to the Central Area. However, within the Central Area, travel time has increased and the variability of service has increased. This has frustrated both the passengers and the operator.

Data on travel times in the Central Area provided by OC Transpo are shown in Table 2.3. These were time counts carried out in November, 1987.

TABLE 2.3

TRAVEL TIME DATA IN CENTRAL AREA

| Street | Albert | Slater | Average |
|---|---|---|---|
| Direction | Westbound | Eastbound | - |
| Origin | Laurier Stn. | Lebreton Stn. | - |
| Destination | Lebreton Stn. | Laurier Stn. | - |
| Distance (km) | 2.57 | 2.57 | 2.57 |
| Travel Time (min:sec) | | | |
| * AM Peak Hour | | | |
| Mean | 9:42 | 10:07 | 9:55 |
| Std. Deviation | 1:26 | 1:34 | - |
| * PM Peak Hour | | | |
| Mean | 11:42 | 11:53 | 11:47 |
| Std. Deviation | 2:08 | 1:50 | - |
| Average Travel Speed (kph) | | | |
| * AM Peak Hour | 15.9 | 15.2 | 15.5 |
| * PM Peak Hour | 13.2 | 12.9 | 13.1 |
| * Average Peak Hour | 14.5 | 14.1 | 14.3 |

The variation in travel time has been such that travel times have ranged up to 20 minutes. As the traffic volumes in the Central Area increase and bus volumes increase, speeds gradually slow down. To compensate, OC Transpo would have to add additional buses. As conditions deteriorate, the reliability of the bus service suffers, and passengers can no longer rely on the published schedule information. Furthermore, the Central Area has only a limited number of locations on narrow sidewalks suitable for bus stops and these areas have to accommodate an increasing number of passengers waiting for delayed buses.

Therefore, the whole problem of low operating speeds now, and the prospect of lower speeds in the future, makes it important to improve travel speeds. Current estimates of travel time improvement in the Central Area with a grade separated transit operation indicates that the time through the Central Area could be cut in half and that schedules could be maintained to provide reliable arrival and departure times.

### 2.3.4 Transfer Requirements

Traditionally, a transfer has been perceived as a detriment to good service levels. A no-transfer trip from work to home is certainly a desirable objective. However, this can only be offered if the level of demand in the suburban area is sufficient to warrant a frequent service. If a suburb can only generate enough passenger flow to support a bus every 30 minutes, then the direct no-transfer trip will have to trade off frequent service and only occur at 30 minute intervals. OC Transpo currently has a planning guideline that allows a direct no-transfer express service if a 10 minute frequency can be maintained in the feeder area. Otherwise, the customer can take a Transitway service at 4 minute frequency, and transfer at the Transitway station to a frequent feeder service for the final leg of the trip home. As an alternative, the rider can use the park and ride, or kiss and ride facilities.

Most areas in the Region now have access to a no-transfer direct express or limited stop service to downtown. The ability of the busway to offer this type of service is one of the prime advantages when compared to rail rapid transit service and is certainly one of the contributing factors to the high level of transit usage in Ottawa-Carleton. It is therefore important that this service feature be preserved.

While it may seem beneficial as an operating strategy to add more and more service to dedicated transitway routes, since in this way the waiting time for passengers in the Central Area can be minimized, additional operating costs are associated with this approach. With this strategy, it is necessary to send more buses to the end of the Transitway than would otherwise be required. One of the features of the bus Transitway strategy is the ability to put in place a very close match between supply of vehicles and demand, thus minimizing the running of empty vehicles to the end of the line.

A second factor affecting the transfer issue, is to locate and arrange transfer points conveniently for the passengers. This includes transfers between surface and grade separated routes, by providing close physical relationships between these services.

### 2.3.5 Station Volumes

Transit passenger volumes to the Central Area will increase. At the present time, there are four main bus stops between Bronson and Elgin to accommodate the passengers. Sidewalk capacity does not pose a problem in the a.m. peak hour as the passengers disperse immediately upon getting off the bus. In the p.m., however, there is currently a problem and it is increasing in magnitude. As the p.m. peak hour volumes increase from approximately 6 500 per direction today to 9 000 and 12 500 in the future, the need for better passenger waiting areas is apparent. The interim measures undertaken provided some rationalization and it is expected that the findings of the concurrent "surface study" will identify a number of physical and operational techniques to alleviate this problem at the passenger waiting areas.

The crowded sidewalks inhibit the ability of the non-transit pedestrians to circulate during peak period bus loading times. An obvious solution is to load at off-street facilities where improvement in the passengers' waiting environment may be possible.

**Exhibit 2.1** indicated the line haul passenger volumes expected by the year 2001 and by 2014, together with the on and off-station volumes for the p.m. peak hour. The peak station, based on p.m. peak hour volumes, will be the Bank Street Station, followed closely by the Metcalfe Street Station. The Rideau Station will be a busy station during the off-peak period times as it enjoys substantial bus transit passenger volumes destined to the Rideau Centre-Market Area. The p.m. peak hour transit passenger volume is the determining factor that influences the width of the platform. The passenger accumulation volumes calculated for Bank Station indicate that a platform width of 6 m would be desirable. At this location, the sidewalk width on Albert or Slater is less than 3.0 m except next to the Met Life Building.

## 2.4 Other Street Users and Uses

Competition for space on the downtown streets of any growing dynamic city will always be intense and the central area of Ottawa is no exception. Curb space requirements for deliveries, couriers, taxi, etc., are obvious, to say nothing of the need for bus loading zones and on-street short-term parking. As the bus volumes increase, the ability of the bus loading area to accommodate the demand is taxed to the limit. There is also the problem of the illegal use of the curb space that compounds bus transit operation.

Congestion on the sidewalks is also a problem. Ottawa has narrow streets in the Central Area and, even with setbacks for the newer developments, many older buildings are built right to the property line. The long range plan of the City calls for more pedestrian amenities which includes wider and more attractive sidewalks. Implementation of a grade separated transitway could assist in this regard if the removal or reduction in the number of surface buses permitted the widening of the sidewalks.

## 2.5 Costs of Congested Street Transit Operation

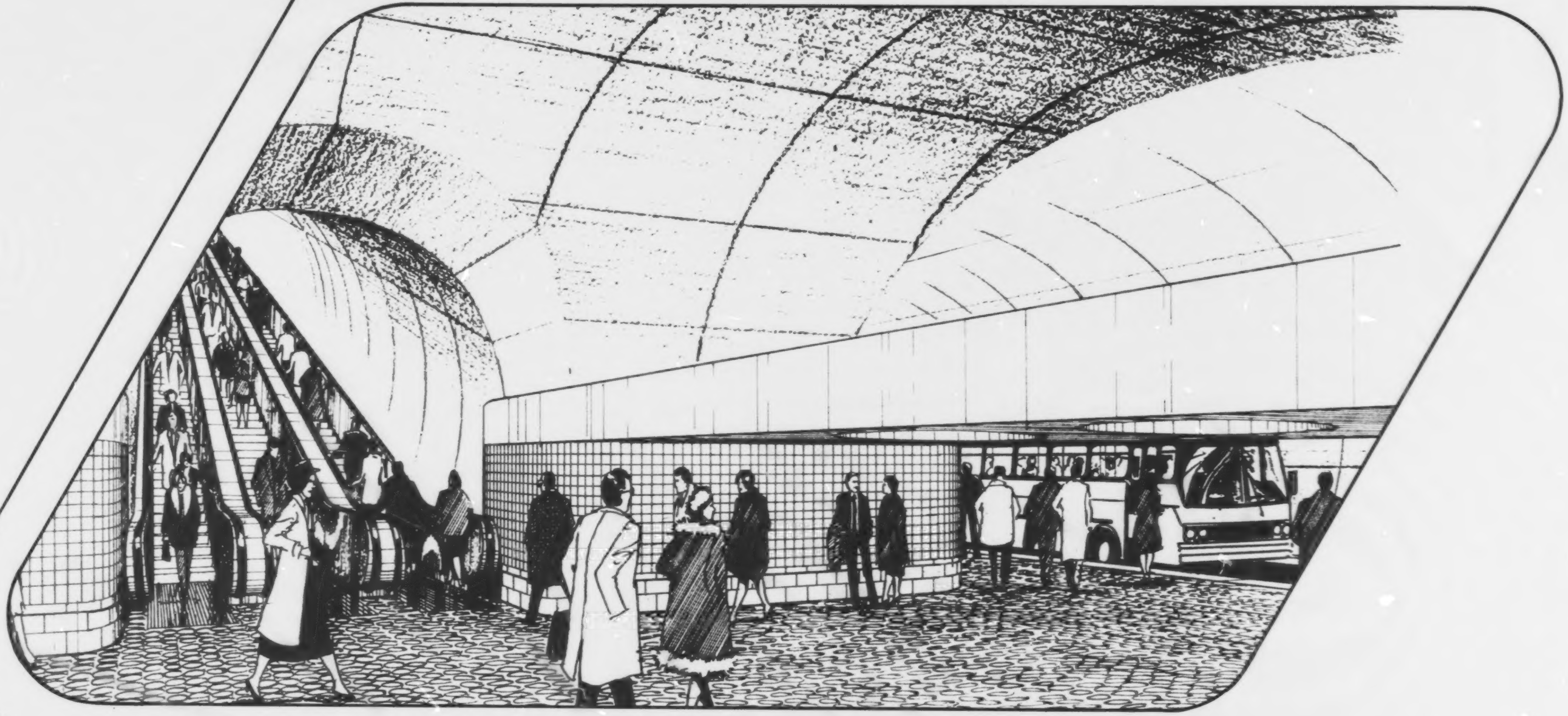
As discussed earlier in this chapter, congested street conditions contribute to a deterioration in transit service levels. This results in lower passenger acceptance and hence a loss in passenger volumes. Congestion also significantly reduces speed of operation and increases costs of operation.

Transit cost increases result from slower speeds which require additional buses to maintain the same service and more garage space to store the extra buses. The long-term impact of lower passenger volumes, however, can carry with it other costs in terms of increased road congestion resulting in a less attractive Central Area. This may encourage a move toward decentralization of some of the existing activity or future growth.

## 2.6 Summary

Current bus and transit passenger volumes during peak travel periods are approaching the capacity of the street system. Adverse impacts on the operation of the transit system are occurring which result in a diminishing level of service through the central area.

Forecasts of employment and travel volumes associated with levels of development in the Official Plan indicate that the existing surface transit operation will be unable to cope with the volumes while maintaining service levels. This most likely will result in transit losing market share of the central area travel. Grade separation through the central area will enable transit to protect its market share and improve the level of service offered to transit passengers.



# CHAPTER 3

# 3.0 CHARACTERISTICS OF A PREFERRED OPTION

## 3.1 Introduction

In this section the desirable attributes of a preferred option are identified. The framework for the evaluation criteria that are used to evaluate the various options is derived from these attributes.

The project rationale is founded on the premise that continued bus transit service through the Central Area on surface streets will lead to a deterioration of service levels that will prejudice existing and future transit ridership and incur greatly increased costs of operation. In addition, the increasing number of buses required to accommodate the increasing passenger volumes, and the growing surface traffic, will lead to a condition where it will be very difficult to physically accommodate the demand. Between now and when this point in time occurs, the RMOC and OC Transpo can put in place certain improvement measures that will provide some operational relief. Those measures are fully described in the concurrent "surface options study". While these measures may provide some degree of relief to the transit operations, they will not provide the ability to accommodate the bus and passenger volumes in the medium to long term. At best, they will "buy some time" until a long term solution can be implemented. Meanwhile, the transit system will continue to incur excessive operating costs in the Central Area because of the slow speeds in the peak periods.

## 3.2 Design Criteria

The following criteria were used as a guide in the development of grade separated options. These criteria are sufficiently specific to permit an assessment of the technical aspects of any option. Further refinements to design of a preferred option will result in modifications either to the criteria or to design elements.

| Criteria | Units | Comments |
|---|---|---|
| Geometric: | | |
| - Design Speed | 80 km/h maximum | These criteria will accommodate bus and rail. |
| - Minimum Curvature | 90 m | |
| - Maximum Grade | 3.5% up, 6% down | |
| - Width of Vehicle | 2.6 m | |
| - Height of Clearance | 4.5 m | |
| Lane Width: | | |
| - Travel Lane | 4.0 m | Allowance for passing lane is provided at stations. |
| - Passing Lane | 3.5 m | |
| Platform: | | |
| - Width | 4.2 m minimum<br>6.0 m desirable at stations with heavy transit user volumes | Passenger accommodation is function of no. of bus routes and frequency. Must make allowance for circulation on the platform for passengers to access different stops. |
| - Length | 110 m | Platform length is intended to provide for storage of disabled bus, and also be long enough to accommodate a 4 bus platoon or LRT train. |
| Fare Collection: | full control | Ability to have full control or proof of payment at various times provides OC Transpo with maximum flexibility. |
| Pedestrian Access: | - escalator<br>- stair<br>- elevator<br>- minimum no. of grade changes | Essential to have all stations fully accessible by persons with mobility impairments. |
| Capacity: | | |
| - bus/hour | up to 240 bus/hour/direction | Reserve capacity is planned beyond needs at 2014 to provide flexibility. |
| - boarding passengers/hour at Central Area Stations | up to 14,000 boarding passengers/hour/direction for total Central Area<br>maximum hourly boarding rate of 4600 at Bank St. westbound | |
| Operations: | single bus and multi bus platoon | Ability to accommodate single bus and multi bus platoon operation provides OC Transpo with maximum flexibility. |
| Bus Breakdown: | disabled bus | Ability to remove disabled bus or bypass it using the space provided at stations will provide operator with the ability to maintain schedules. |
| Convertability: | - compatible with LRT geometric standards<br>- compatible to maximum degree with Heavy Rail | Provide flexibility for future. Curvature at critical location to be reviewed in functional design. |
| Station Access: | spread access points | Ability to spread station access points to various appropriate locations in the downtown will provide maximum degree of coverage in the Central Area. |
| Development Compatibility: | economic strength | Ability to contribute to the economic strength of the downtown will provide a reliable transit system that can be attractive to the transit user. |
| Implementation: | minimum surface disruption | Minimize surface disruption to transit service, street traffic and adjacent land uses during and after construction. |

### 3.3 Capacity and Level of Service

The first requirement for any improvement measure will be that it provide an adequate capacity to accommodate the estimated future transit bus and passenger volumes, at an acceptable level of service for both transit and non-transit travel.

The transit passenger forecast, as prepared by RMOC and OC Transpo, indicates that the facility should be able to provide for the passenger and bus volumes shown in Table 3.1.

TABLE 3.1

ESTIMATED ONE-WAY BUS AND TRANSIT
PASSENGER VOLUMES
EXITING CENTRAL AREA IN P.M. PEAK HOUR

| Year | Transit Passengers P.M. Peak Hour (One Way) | No. of Articulated Buses at 70 Passenger Capacity P.M. Peak Hour (One Way) | |
|---|---|---|---|
| 1995 | 8 000 | 180 | (L.F. 0.63)<br>(Load Factor) |
| 2001 | 9 500 | 181 | (L.F. 0.75) |
| 2014 | 12 500 | 238 | (L.F. 0.75) |

The bus volumes assume that all articulated vehicles are used. The a.m. peak hour volumes are approximately 15 percent higher, but the unloading operation is less demanding on the station dwell time. The 2001 volumes are a product of the Official Plan analysis and are compatible with a Regional population of 725,000 and Central Area employment of 95 000. The 2014 values are an extrapolation of the trends to 2001. The influence of this growth on the Transitway capacity in the Central Area is hard to determine, as it will depend upon where the additional employment locates. If significant growth in employment continued to occur in the Central Area, then the capacity beyond 2001 must be available to meet it. If the employment growth takes place at other centres or nodes serviced by the transitway then this may require more through trips which will also require greater capacity. Alternatively, if employment growth beyond 2001 takes place in locations remote from transit service, little impact on the downtown core will result except that transit will lose market share. However, it appears reasonable to provide for increased service capacity to accommodate yet unknown growth patterns.

The level of service provided by a new facility must be a significant improvement over that now provided, and that means the following:

- speeds compatible with the rest of the grade separated transitway;
- opportunities to improve on schedule reliability;
- adequate space for passenger waiting areas;
- opportunity to utilize full fare security or proof of payment;
- good distribution of station access points along the length of the corridor.

In addition to providing sufficient bus and passenger capacity, the preferred option should provide or protect the capacity of the existing roadway infrastructure. In this regard, the preferred grade separated option theoretically provides at least two new lanes of actual street capacity by virtue of removing or reducing the number of buses from the lanes on Albert, Slater, Queen and Wellington Streets that they currently occupy.

### 3.4 Compatibility with Development

The corridor for the proposed grade separated transitway between Booth Street and the existing Campus Station traverses a range of land uses and developments. The east-west corridor opportunities extend from Queen

Street south to Slater Street in a broad swath through the Central Area. A brief summary of the nature of the areas follows:

Booth Street to the Escarpment:

This is an area of future redevelopment by the NCC in cooperation with other governments. The area between the residential zones to the south and the river to the north has been designated for open space and public park use. The Ottawa River Parkway and the proposed Bronson-Portage connection will utilize some space and may impact on the escarpment face. The pumping station and associated water ways are significant and should be respected. The area will be an important open space area with good views across to Quebec and the Gatineau Hills.

Escarpment:

This prominent feature is a major landmark and provides a very real definition to the western end of the Central Area. It should be respected to the maximum extent possible and any of the options that impinge on it should be subject to very careful landscape controls.

Bronson to Lyon:

This is an area of high density residential land use. Within it are several heritage properties and precincts along Queen and Albert Streets at the Bronson end of the area. It is developing as a desirable downtown residential area and its population can contribute to the on-street pedestrian activity. The developing residential area may be affected by the heavy traffic volumes in part due to transit operations. There are a number of major properties in this area that are available for redevelopment. Reduction of through traffic volumes would be beneficial.

Lyon to Elgin:

This is the heart of the Central Area which is approximately five blocks long by 5 or 6 blocks wide in the north-south direction. Within this area are the major concentrations of highrise office and hotel developments and street related retail and commercial activities of the Region.

There are a number of potential development and redevelopment sites along this section, many of which front on either Albert or Slater. Some are already programmed for early construction, such as Canlands. The opportunity to access or interface with some of these sites will be a desirable objective. Not all are located where easy access to stations can be gained, but many are ideally suited. Also, to the extent that the Transitway can support and strengthen existing preferred development, such as on Bank Street, then the facility will be beneficial to other urban planning goals.

Elgin Street Corridor:

This is a major north-south facility and forms a part of the Confederation Boulevard. It is the only wide street that provides especially open and important views north to the War Memorial, the Chateau Laurier and to the East Block of Parliament. Important buildings, like the National Arts Centre and the heritage buildings on the west side of Elgin opposite the War Memorial face Elgin. The street is an impressive urban street with significant potential for major attractions.

Elgin to the Canal:

This area contains very important open space in the form of Confederation Park and the area around the NAC. Driveways, pedestrian facilities and the Canal itself represent some of the most intensively used "people" space in the Central Area. This corridor to the north provides unsurpassed unique views of the Parliamentary precinct.

East of Canal to Campus Station:

This area contains a variety of uses from a large office complex, Department of National Defence Building, the major Rideau Centre and Congress Centre, a scattering of heritage buildings, the northern end of the University of Ottawa campus and some developing residential uses. The area has a charm which is carried over from the historic area east of the corridor. It also contains a significant internal development combining the Rideau Centre, Westin Hotel and Congress Centre which represents a major destination for many employees, shoppers and tourists. The direct connection to Rideau Street and the Market area increases its attractiveness.

The transitway proposals must support the variety of land uses and developments through the Central Area. They should also enable, enhance and encourage full development of various parcels of land that are located within the area of direct influence. The Transitway must also respect the important features of existing development and encourage development initiatives by providing a safe, fast and efficient transportation facility for workers, shoppers and visitors from all sectors of the region.

### 3.5 Flexibility

Operational flexibility is a desirable feature of transit systems. The existing surface bus operation provides significant flexibility in that the buses can use all the lanes on the street, even though they have a bus-only lane for their use. In addition, a major accident or event that ties up a street can be accommodated by re-routing of buses. This is more difficult with trolley buses or fixed route systems. A disabled or out of service bus can be left on street until it can be removed and buses can bypass the vehicle without significant delays. Thus a desirable option would provide operational flexibility to accommodate unforeseen events in the most efficient way with the least inconvenience to passengers and other roadway users.

In addition, the preferred option should recognize that there may be unforeseen changes over the next 50 years or so, and these may very well include improved vehicular technology. The opportunity to take advantage of these unknown developments must be protected. Thus, in terms of flexibility, the perferred option should use geometrics, grades, curve radii and clearance envelopes that are generous, recognizing the impact on costs. In some instances, this flexibility can be provided up front and in others, it can be provided by future modifications that are not initially designed into the facility.

Another element of flexibility that a preferred option should exhibit is in the arrangement of the passenger flows from the streets to the fare paying areas. OC Transpo uses both proof of payment and conventional fare collection in its operation. The station designs should permit the maximum amount of flexibility in this regard while minimizing the manpower requirements. The fare collection system must also be very clearly understood by all passengers.

### 3.6 Ease of Implementation

Desirably a grade separated option should be capable of being put in place and opened for service with a very minimum of disruption to everyday life in the Central Area. That implies that existing traffic, transit, pedestrians, business and retail life would not be significantly affected by the major construction works. However, with a project of this magnitude located in the very heart of the City, some impact and inconvenience will be inevitable. Depending on the method of construction and on the alignment chosen, the impacts can be very significant in terms of street construction, difficult pedestrian and vehicular detours, loss of street capacity, dirt, dust, noise, etc., all of which have different levels of impact on the Central Area and the people working, shopping and doing business there. The key concerns of businesses and retailers are related to access to their establishments. Many of the convenience store retailers rely heavily on walk-in traffic to support them and they would be severely affected by any disruption to this access.

There is also a potential major impact on the transit operations if Albert or Slater are significantly affected. The transit system struggles now with schedule reliability and travel speeds. Any reduction in available roadway space would adversely affect the operation. Thus, a desirable option would be one that causes the minimum amount of surface street disruption, for the minimum amount of time.

### 3.7 Integration into the Central Area

The preferred Transitway option will be a catalyst in that it should be able to support and strengthen other Central Area developments. It should be seen in its role as a supporting component of the transportation system that adds to the attractiveness and desirability of the Central Area. To accomplish this, the Transitway must be part of an overall urban strategy, not just an element in its own right. The preferred option must exhibit a great deal of flexibility in terms of how it can evolve over time as new developments and opportunities occur.

The preferred option should provide for significant accessibility throughout the Central Area by providing a good distribution of access and egress points. These can be integrated into the streetscape or provided within adjacent commercial development as opportunities present themselves. The pedestrian connections to stations and through stations should be able to perform a key role in directing pedestrian activity to nodes within the Central Area that need to be reinforced or are destinations in themselves.

### 3.8 Support for Transportation Planning Objective of Others

The City of Ottawa and the National Capital Commission both have a major interest in the developments associated with the Central Area Transitway. The Central Area Transitway represents a major urban design and transportation element that can influence other transportation and urban design efforts. The opportunity exists for this Transitway to be supportive of these other interests.

Some of the transportation related interests of the City and the NCC are listed below. To the extent that the Central Area Transitway can support them, its construction will be seen as a positive force.

- Removal of buses from the major elements of the Confederation Boulevard

  The NCC has plans for the redevelopment of Wellington and Elgin Streets. It would be a positive step if the Central Area Transitway was able to facilitate this project by freeing up space on other streets to allow the transfer of bus routes from Wellington Street to occur. This could also be achieved if a new method of operations was developed that resulted in fewer buses traversing the area.

- Strengthen pedestrian linkages to Sparks Street

  Sparks Street Mall is an exciting urban pedestrian mall that has recently undergone a major overhaul. It is important to keep the Mall active and attractive and this could be enhanced if the Transitway was able to direct or facilitate the flow of people to the Mall by means of pedestrian linkages to the Mall.

- Encourage pedestrian activity that will support the street level retail

  The City and the NCC have expressed concern regarding the possible development of large underground retail that could adversely affect surface level activity. The Central Area Transitway can be a positive force to support surface activities through the design of good pedestrian connections and enable wider sidewalks to be developed. The scale of transit operation is significantly less than the Metro systems in Montreal and Toronto with the result that extensive retail in the transit stations is not warranted or planned.

- Encourage the rehabilitation of City streets to more attractive, people oriented facilities without the adverse effects of lost capacity

  For a variety of reasons, some of the downtown streets are not attractive, inviting, exciting, people oriented streets with appealing landscaping and streetscaping.

  The Central Area Transitway may be able to assist in this regard because in essence, it introduces a new two lane arterial facility into a very busy downtown, and removes from the surface streets 360-400 buses in the peak hour. This will free up road capacity in the downtown that can be utilized to provide widened sidewalks and urban ammenities.

  However, the "freed up" capacity may have to be shared with several competing demands, i.e. Wellington Street and Albert/Slater. There will still be some buses on surface streets, as neither the CTCRO buses or the OC Transpo Bank/Elgin - Rideau services will be accommodated on the Central Area Transitway.

- Protect Views

  The NCC and others are vitally interested in the existing views and vistas. The transitway should not impinge on the views and vistas, and by removing a large number of buses from the surface the transitway should reduce the blockages of the long strings of buses on surface streets.

- Encourage a higher modal split to the Central Area

  This objective has, as its underlying theme, the reduction of the use of the auto in the Central Area. This would enable the roadway facilities to avoid the worst of roadway congestion at peak periods. The reduction in congestion may also encourage off-peak traffic to use the short term parking facilities and shop or conduct business in the area.

  To increase the modal split, the total transit system has to be more attractive to the customer. The provision of a well designed, operationally efficient grade separated Central Area Transitway can assist in that regard.

### 3.9 Economic Feasibility

The development of a grade separated Transitway through the Central Area of the busy Nation's Capital will be an expensive undertaking. However, it is worthy of note that there is no other transit system in North America which carries as many or more peak period passengers as OC Transpo that is not already grade separated. The City of Seattle is currently engaged in a similar project which involves building a 2.2 km facility through the central area at a cost of over $400 million U.S. This facility is planned to accommodate significantly fewer buses than the RMOC project.

The project must exhibit net savings from operations, bus capital needs, user time savings and benefits to other traffic, such that the decision to proceed is based on sound economic grounds. The costs of not proceeding must be taken into account in arriving at the net benefits.

The identification and quantification of benefits must be done in a manner that uses conventional techniques that are clearly acceptable to the decision makers and funding organizations. The preferred option should demonstrate these economic benefits in a clear way, quantify the time series of benefits using as the base case the status quo, or continued surface operation.

To some extent the base case scenario is theoretical, as at some point it clearly becomes physically impossible to continue on the surface. At that point some major changes would have to be made in order to continue surface operations. These changes could involve using additional streets for bus traffic through the Central Area, or a reduction in the planned Central Area activity. In the base case economic analysis, the surface operation must be assumed to stablize at some slow speed of operation, the peak period must be extended and somehow the buses must continue to get through.

Elements in the Economic analysis should include:

- direct bus operating costs in the Central Area, for both peak and off-peak periods;
- direct bus capital cost savings available if Central Area Transitway operations result in the need for fewer buses. This will also include capital savings associated with garage requirements;
- direct transit passenger time savings during peak and off-peak periods;
- direct vehicle operating cost savings to other road users who benefit from additional capacity made available during peak periods;
- direct user time savings realized by other road users due to additional road capacity;
- direct financial impact on the businesses along the selected route both during implementation and after the project is completed;
- direct financial impact on the tax base due to the project;
- benefits of other downtown projects that are attributable to the Transitway.

# CHAPTER 4

# 4.0 FINDINGS AND RECOMMENDATIONS

## 4.1 Background

This chapter presents a summary of the major findings.

Three essentially different options were examined: elevated Transitway; shallow underground Transitway constructed by cut & cover technique; and a tunnel. A wide range of technical issues was identified and addressed in the study. Among these issues were:

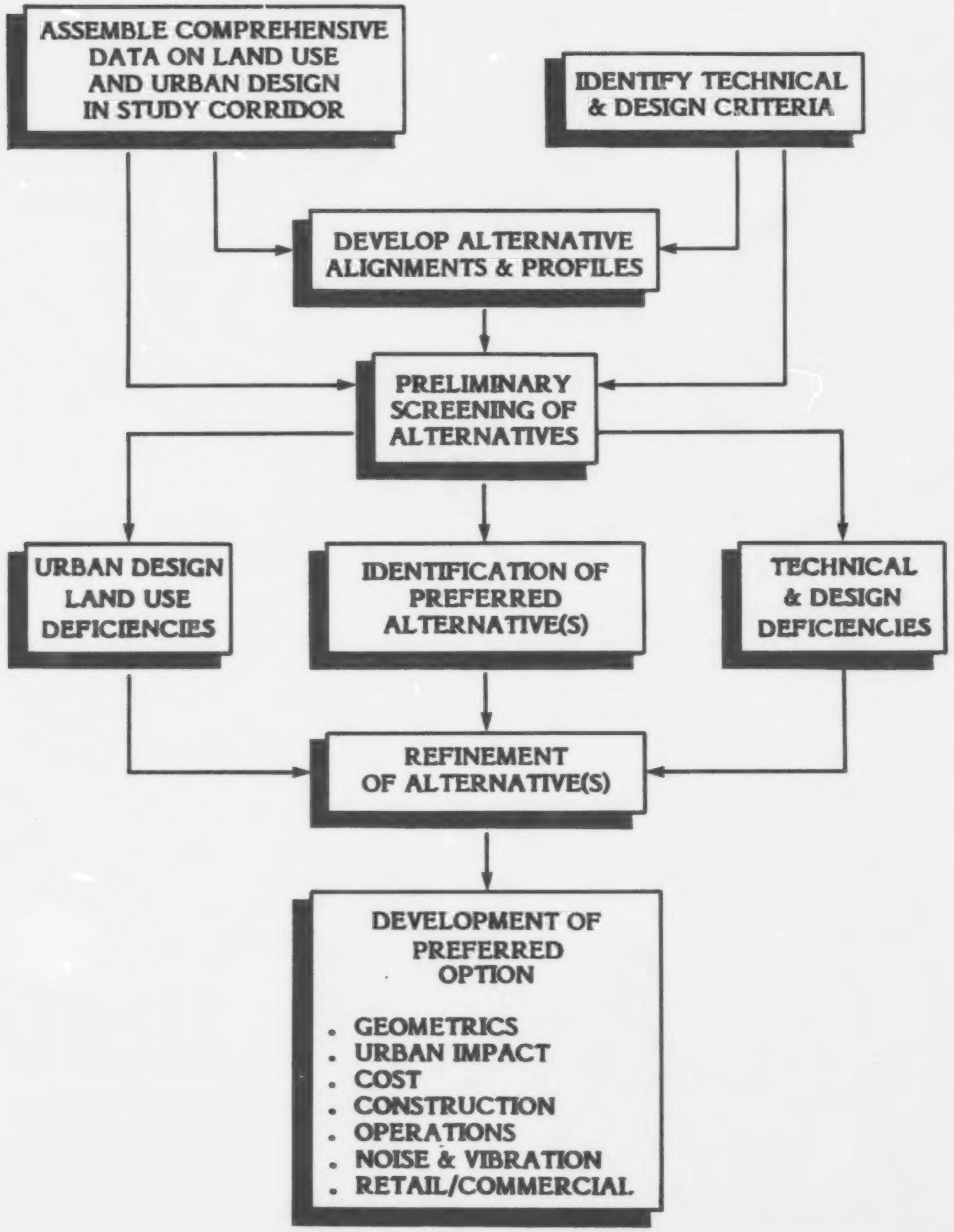
- alignment through Central Area between Wellington and Slater;
- alignment east of Canal;
- geology & geotechnical conditions;
- utility infrastructure;
- urban design values & impacts;
- retail & commercial impacts;
- operational capacity & flexibility;
- vehicle/fuel technology;
- ventilation requirements;
- fume dispersal requirements;
- noise & vibration impact;
- station concepts & integration potential.

Maximum use was made of existing technical data but in a number of cases additional data collection was required, supplemented by many site visits by the study team members.

The study utilized an approach that is briefly described in **Exhibit 4.1** - Option Development Process. In this approach, various schemes were progressively developed and evaluated until a preferred alternative was identified for each of the three basically different options - elevated, cut/cover & tunnel.

The three preferred options were then refined and comparative cost analyses undertaken for evaluation purposes. Finally, a detailed comparison of the three preferred options was conducted to identify the recommended scheme.

**EXHIBIT 4.1**


ASSEMBLE COMPREHENSIVE DATA ON LAND USE AND URBAN DESIGN IN STUDY CORRIDOR
IDENTIFY TECHNICAL & DESIGN CRITERIA
DEVELOP ALTERNATIVE ALIGNMENTS & PROFILES
PRELIMINARY SCREENING OF ALTERNATIVES
URBAN DESIGN LAND USE DEFICIENCIES
IDENTIFICATION OF PREFERRED ALTERNATIVE(S)
TECHNICAL & DESIGN DEFICIENCIES
REFINEMENT OF ALTERNATIVE(S)
DEVELOPMENT OF PREFERRED OPTION
. GEOMETRICS
. URBAN IMPACT
. COST
. CONSTRUCTION
. OPERATIONS
. NOISE & VIBRATION
. RETAIL/COMMERCIAL

**OPTION DEVELOPMENT PROCESS**

## 4.2 Recommended Scheme

The recommended Transitway scheme is a twin rock tunnel through the Central Area on Waller and Daly east of the Canal and on Slater and Albert Streets west of the Canal. This scheme is illustrated on **Exhibit 4.2a Albert St., and 4.2b Slater St.** Briefly, the scheme is described as follows.

### 4.2.1 Alignment

The Transitway proceeds north from the existing surface Campus Station and descends to underpass Laurier Avenue. This initial section is constructed using retaining walls and a cut-cover construction technique. This section consists of separate bus tunnels for each direction of travel which cross over each other and continue to descend at 3.5 percent north along Waller and west into Daly Street. A station is developed under Daly Street just to the immediate east of the Rideau Centre and connected to it. This station would be a centre platform type station. The two bus tunnels would upon leaving the Rideau Station, pass under the Canal with approximately 10 m clearance and proceed under a portion of the National Arts Centre (NAC), with 10 m of solid rock between the roof of the Transitway tunnel and the NAC. The two tunnels would proceed under Albert Street and Slater Street through the Central Area then exit through the escarpment west of Bronson Avenue. Two tunnels would cross over and approach the Lebreton Station in the conventional lane arrangement. Through the Central Area, the tunnel platform and running way would be approximately 17 m below the surface of the streets and 10 to 13 m in the solid limestone rock. Along the transitway, the maximum grades are short sections of 3.5%, and minimum curvature radius is 100 m. This minimum curvature occurs between the Rideau Centre Station and Waller Street where buses are at a reduced speed as they approach or leave the station.

### 4.2.2 Cross-section

The Transitway will utilize twin tunnels approximately 6.3 to 7.6 m in diameter depending upon ground conditions and construction techniques. In the approaches to the tunnel proper, the sections would utilize open cut and cut & cover construction techniques with a 10.8 to 11.4 m width. At stations in the Central Area, the tunnel cross-section would be widened to approximately 14 m to accommodate a platform (6.0 m), bus lane (4.0 m) and a passing lane (3.5 m). In all cases, the Transitway can be constructed under the street right-of-way or at a sufficient depth (between Rideau Centre Station and Elgin Street) that minimal construction impacts on buildings are foreseen. Typical cross-sections are illustrated on **Exhibits 4.3a & b.**

### 4.2.3 Stations

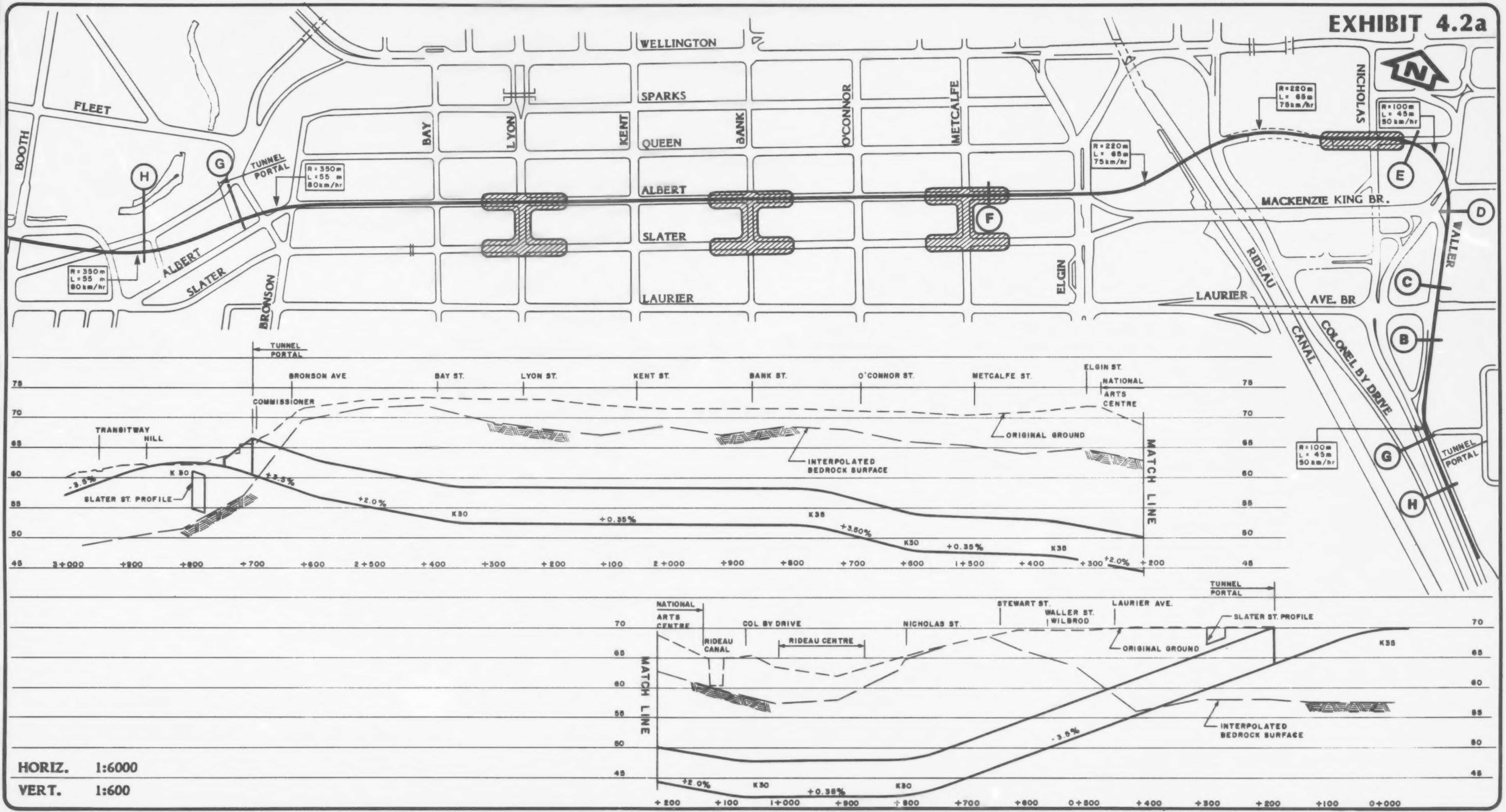
Four stations are planned. Rideau Centre Station would be a centre platform station developed under Daly Avenue. The station would feature connections up to the Rideau Centre Complex. The other three stations are located approximately as follows:

- under Metcalfe Street, in the block between Albert Street and Slater Street;
- under Bank Street, in the block between Albert Street and Slater Street;
- under Lyon Street, in the block between Albert Street and Slater Street.

The stations can be developed entirely under the street right-of-way (Metcalfe, Bank, Lyon), or should the opportunity exist, through a parcel of land between Albert Street and Slater Street located close to the cross street stations indicated. A typical station concept, in this case under the Bank Street right-of-way between Albert Street and Slater Street, is illustrated on **Exhibits 4.4 and 4.5.**

The station platforms are 110 m long and have a width of 6 m. There is a 4.0 m bus loading lane and a 3.5 m passing lane at each platform on Albert

**EXHIBIT 4.2a**

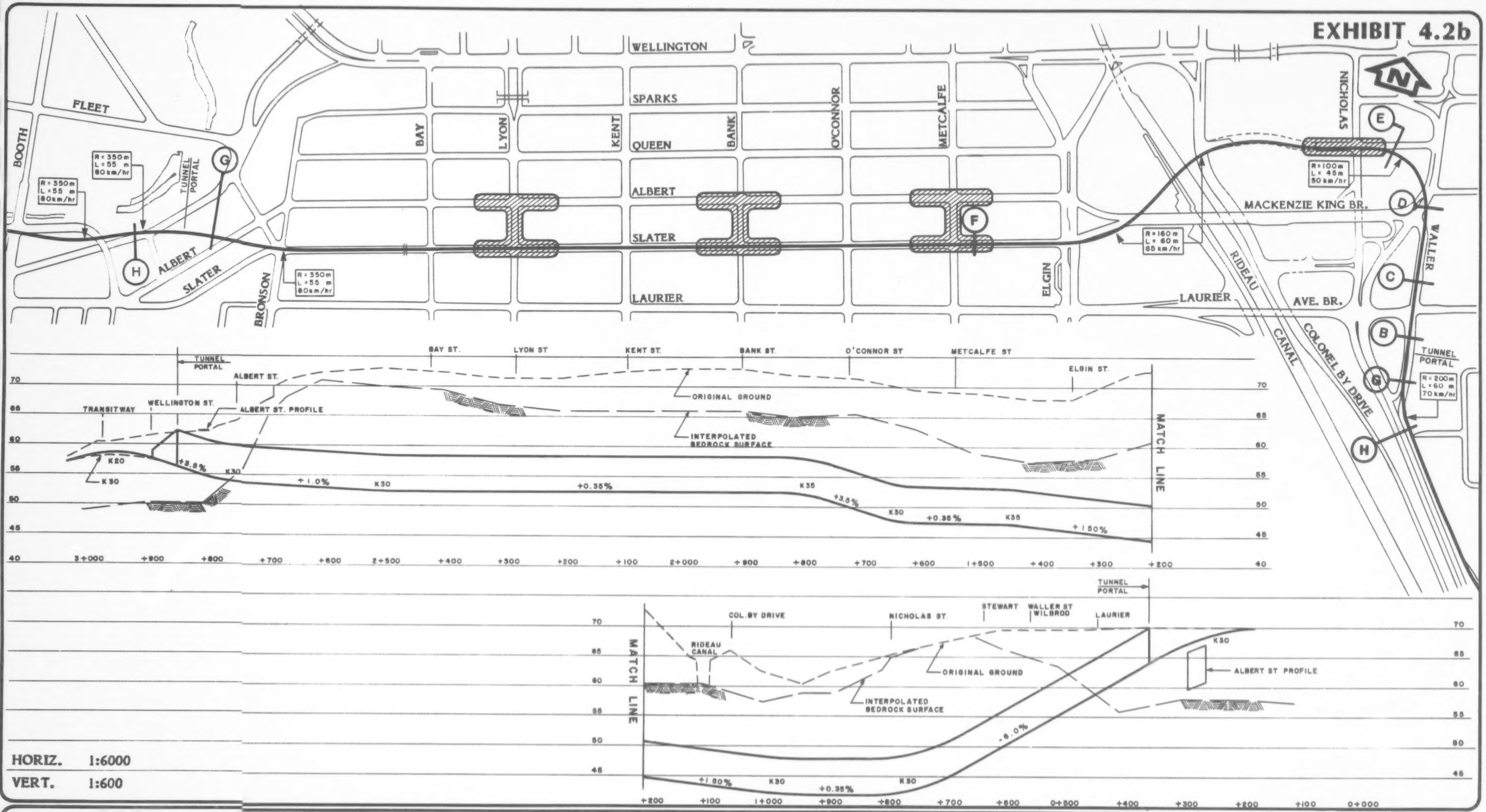

WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
FLEET
BOOTH
BRONSON
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
NICHOLAS
WALLER
MACKENZIE KING BR.
LAURIER AVE. BR
RIDEAU CANAL
COLONEL BY DRIVE
TUNNEL PORTAL
N
R = 350m L = 55 m 80 km/hr
R = 220m L = 68m 75 km/hr
R = 100m L = 45m 50 km/hr
A
B
C
D
E
F
G
H
TUNNEL PORTAL
BRONSON AVE
COMMISSIONER
BAY ST.
LYON ST.
KENT ST.
BANK ST.
O'CONNOR ST.
METCALFE ST.
ELGIN ST.
NATIONAL ARTS CENTRE
TRANSITWAY
HILL
SLATER ST. PROFILE
ORIGINAL GROUND
INTERPOLATED BEDROCK SURFACE
MATCH LINE
-3.5%
+3.5%
+2.0%
+0.35%
+3.50%
K30
K35
75
70
65
60
55
50
45
3+000
+900
+800
+700
+600
2+500
+400
+300
+200
+100
2+000
1+500
NATIONAL ARTS CENTRE
RIDEAU CANAL
COL. BY DRIVE
RIDEAU CENTRE
NICHOLAS ST.
STEWART ST.
WALLER ST. WILBROD
LAURIER AVE.
1+000
0+500
0+000
HORIZ. 1:6000
VERT. 1:600

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
**DELCAN** / KLOHN LEONOFF

## RECOMMENDED SCHEME

TUNNEL OPTION
SCHEME 5
PLAN & PROFILE
ALBERT STREET

EXHIBIT 4.2b



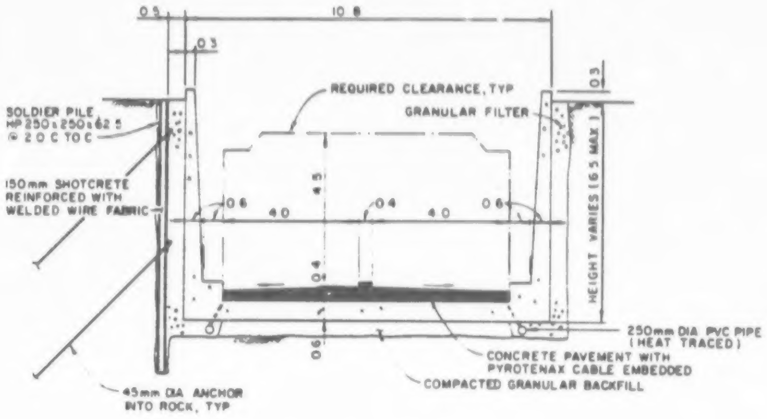
WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
FLEET
BOOTH
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
BRONSON
NICHOLAS
WALLER
MACKENZIE KING BR.
LAURIER AVE. BR.
RIDEAU CANAL
COLONEL BY DRIVE
TUNNEL PORTAL
R = 350m L = 55 m 80km/hr
R = 350m L = 55 m 80km/hr
R = 350m L = 55 m 80km/hr
R = 160m L = 60m 65km/hr
R = 100m L = 45m 50km/hr
R = 200m L = 60 m 70km/hr
A
B
C
D
E
F
G
H
TRANSITWAY
WELLINGTON ST.
ALBERT ST.
ALBERT ST. PROFILE
BAY ST.
LYON ST
KENT ST.
BANK ST.
O'CONNOR ST
METCALFE ST
ELGIN ST.
ORIGINAL GROUND
INTERPOLATED BEDROCK SURFACE
MATCH LINE
K20
K30
K35
+3.5%
+1.0%
+0.35%
+1.50%
COL. BY DRIVE
RIDEAU CANAL
NICHOLAS ST.
STEWART
WALLER ST
WILBROD
LAURIER
-6.0%
HORIZ. 1:6000
VERT. 1:600

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN** / KLOHN LEONOFF

# RECOMMENDED SCHEME

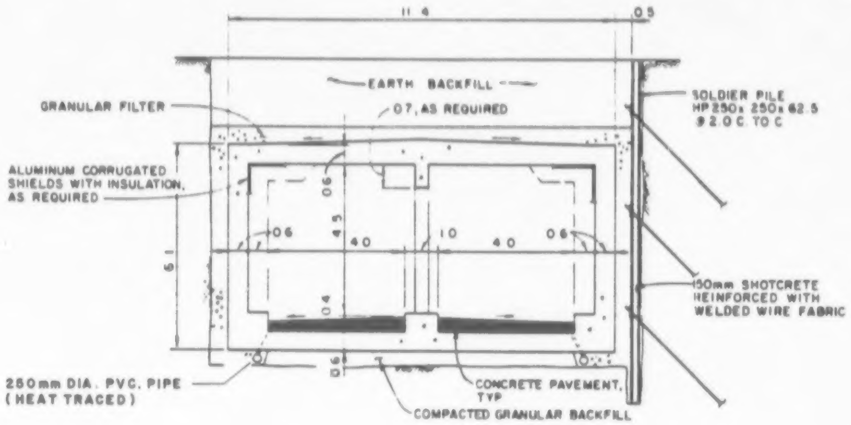
## TUNNEL OPTION
## SCHEME 5
## PLAN & PROFILE
## SLATER STREET

**EXHIBIT 4.3a**


0.5
10.8
0.3
0.3
SOLDIER PILE HP250x250x62.5 @ 2.0 C TO C
150mm SHOTCRETE REINFORCED WITH WELDED WIRE FABRIC
REQUIRED CLEARANCE, TYP
GRANULAR FILTER
0.6
4.0
0.4
4.0
0.6
4.5
0.4
0.6
HEIGHT VARIES (6.5 MAX)
250mm DIA PVC PIPE (HEAT TRACED)
CONCRETE PAVEMENT WITH PYROTENAX CABLE EMBEDDED
COMPACTED GRANULAR BACKFILL
45mm DIA ANCHOR INTO ROCK, TYP

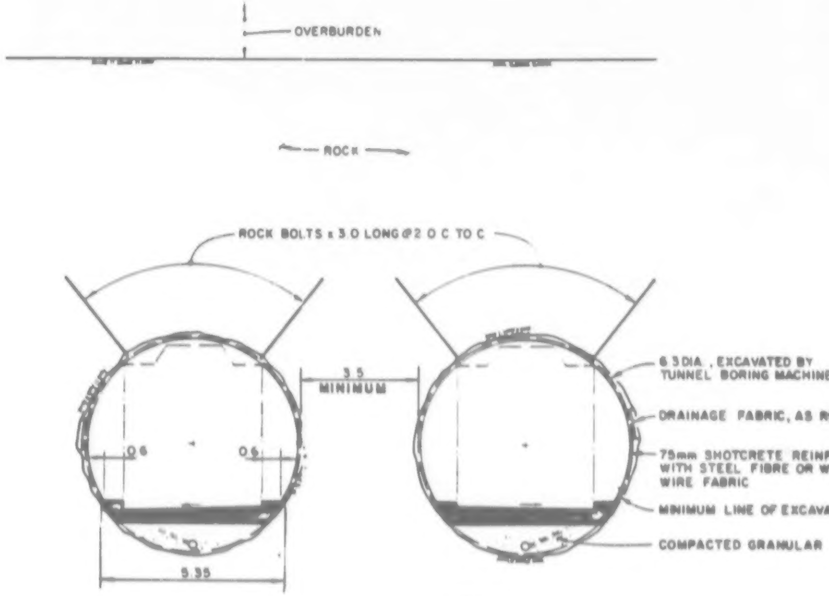
SECTION (A)

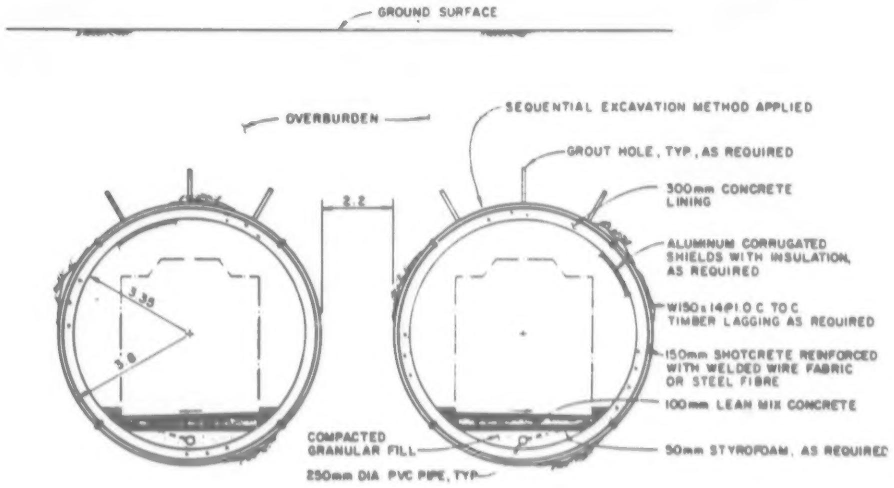
OPEN CUT - BOTH DIRECTIONS


11.4
0.5
EARTH BACKFILL
GRANULAR FILTER
0.7, AS REQUIRED
SOLDIER PILE HP250x 250x 62.5 @ 2.0 C. TO C
ALUMINUM CORRUGATED SHIELDS WITH INSULATION, AS REQUIRED
0.6
4.5
6.1
0.6
4.0
1.0
4.0
0.6
0.4
0.6
150mm SHOTCRETE REINFORCED WITH WELDED WIRE FABRIC
250mm DIA. PVC. PIPE (HEAT TRACED)
CONCRETE PAVEMENT, TYP
COMPACTED GRANULAR BACKFILL

SECTION (B)

CUT AND COVER SECTION USED TO TRANSITION TO TUNNEL IN SHALLOW GROUND


OVERBURDEN
ROCK
ROCK BOLTS x 3.0 LONG @ 2.0 C TO C
3.5 MINIMUM
0.6
0.6
5.35
6.3 DIA., EXCAVATED BY TUNNEL BORING MACHINE
DRAINAGE FABRIC, AS REQUIRED
75mm SHOTCRETE REINFORCED WITH STEEL FIBRE OR WELDED WIRE FABRIC
MINIMUM LINE OF EXCAVATION, TYP
COMPACTED GRANULAR FILL


GROUND SURFACE
OVERBURDEN
SEQUENTIAL EXCAVATION METHOD APPLIED
GROUT HOLE, TYP, AS REQUIRED
2.2
3.35
3.8
300mm CONCRETE LINING
ALUMINUM CORRUGATED SHIELDS WITH INSULATION, AS REQUIRED
W150x14@1.0 C TO C TIMBER LAGGING AS REQUIRED
150mm SHOTCRETE REINFORCED WITH WELDED WIRE FABRIC OR STEEL FIBRE
100mm LEAN MIX CONCRETE
COMPACTED GRANULAR FILL
50mm STYROFOAM, AS REQUIRED
250mm DIA PVC PIPE, TYP

SECTION (C)

TWIN TUNNELS IN GROUND
WHERE SUPPORT IS REQUIRED

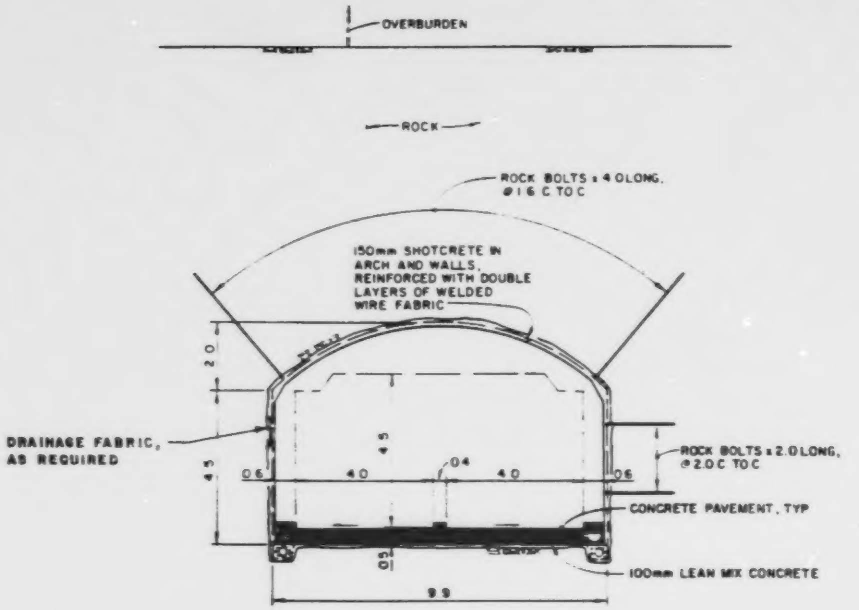
SECTION (D)

TWIN TUNNELS IN ROCK
TYPICAL T.B.M. SECTION
TYPICAL SECTION UNDER ALBERT/SLATER
WITH INCREASED SEPARATION BETWEEN TUNNELS

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / KLOHN LEONOFF

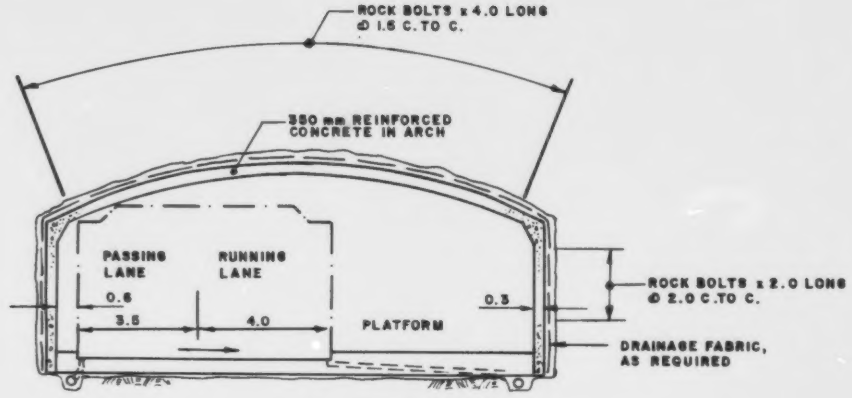
## TUNNEL OPTION
## VARIOUS CROSS SECTIONS

**EXHIBIT 4.3b**


OVERBURDEN
ROCK
ROCK BOLTS x 4.0 LONG, @ 1.6 C TO C
150mm SHOTCRETE IN ARCH AND WALLS, REINFORCED WITH DOUBLE LAYERS OF WELDED WIRE FABRIC
2.0
4.5
4.5
DRAINAGE FABRIC, AS REQUIRED
0.6
4.0
0.4
4.0
0.6
ROCK BOLTS x 2.0 LONG, @ 2.0 C TO C
CONCRETE PAVEMENT, TYP
0.5
100mm LEAN MIX CONCRETE
9.9

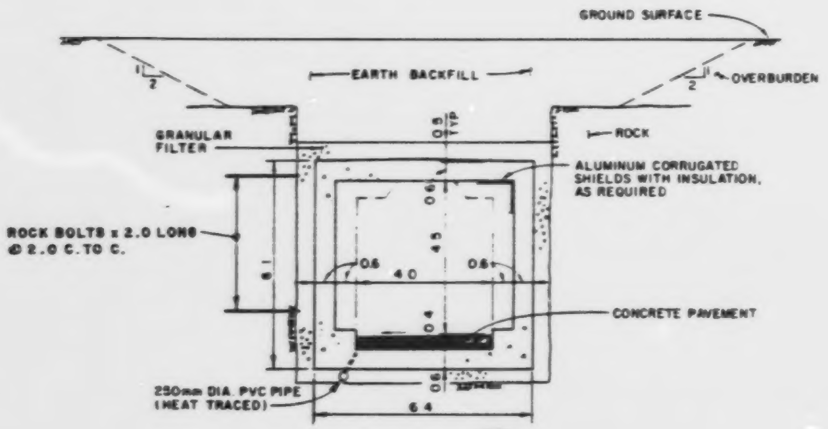
SECTION E

TWO WAY CROSS SECTION IN ROCK


ROCK BOLTS x 4.0 LONG @ 1.5 C. TO C.
350 mm REINFORCED CONCRETE IN ARCH
PASSING LANE
RUNNING LANE
0.6
3.5
4.0
PLATFORM
0.3
ROCK BOLTS x 2.0 LONG @ 2.0 C. TO C.
DRAINAGE FABRIC, AS REQUIRED

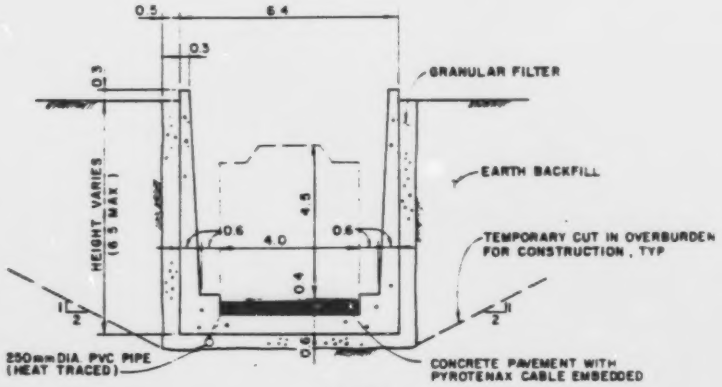
SECTION F

TYPICAL SECTION ALONG A PLATFORM
IN ROCK EXCAVATION


GROUND SURFACE
EARTH BACKFILL
1
2
OVERBURDEN
0.5 TYP
ROCK
GRANULAR FILTER
ALUMINUM CORRUGATED SHIELDS WITH INSULATION, AS REQUIRED
0.6
4.5
ROCK BOLTS x 2.0 LONG @ 2.0 C. TO C.
6.1
0.6
4.0
0.6
0.4
CONCRETE PAVEMENT
250mm DIA. PVC PIPE (HEAT TRACED)
0.6
6.4

SECTION G

TYPICAL ONE WAY CUT/COVER SECTION


0.5
6.4
0.3
0.3
GRANULAR FILTER
HEIGHT VARIES (6.5 MAX)
EARTH BACKFILL
4.5
0.6
4.0
0.6
TEMPORARY CUT IN OVERBURDEN FOR CONSTRUCTION, TYP
0.4
1
2
250mm DIA. PVC PIPE (HEAT TRACED)
0.6
CONCRETE PAVEMENT WITH PYROTENAX CABLE EMBEDDED

SECTION H

TYPICAL OPEN CUT ONE WAY SECTION

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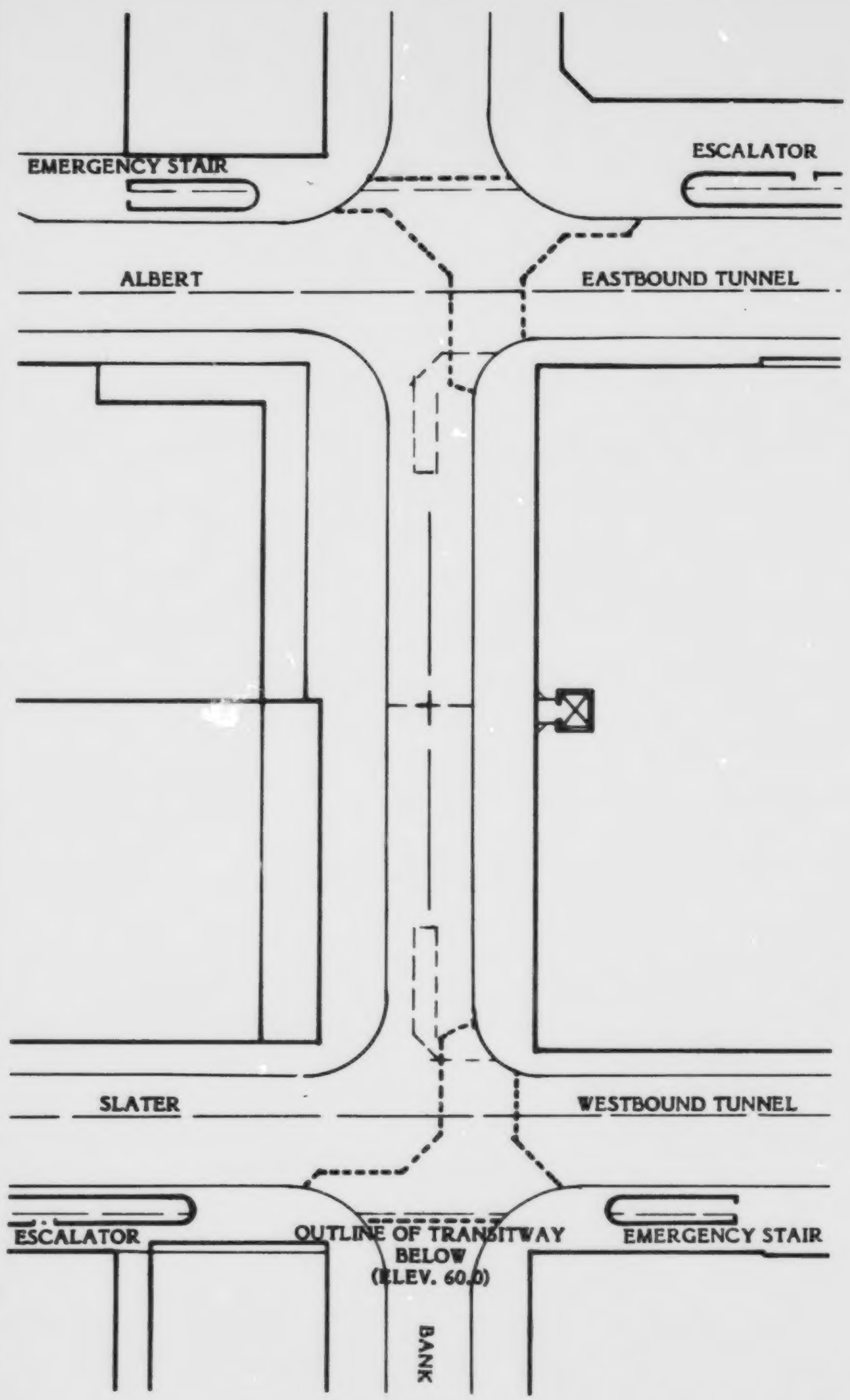
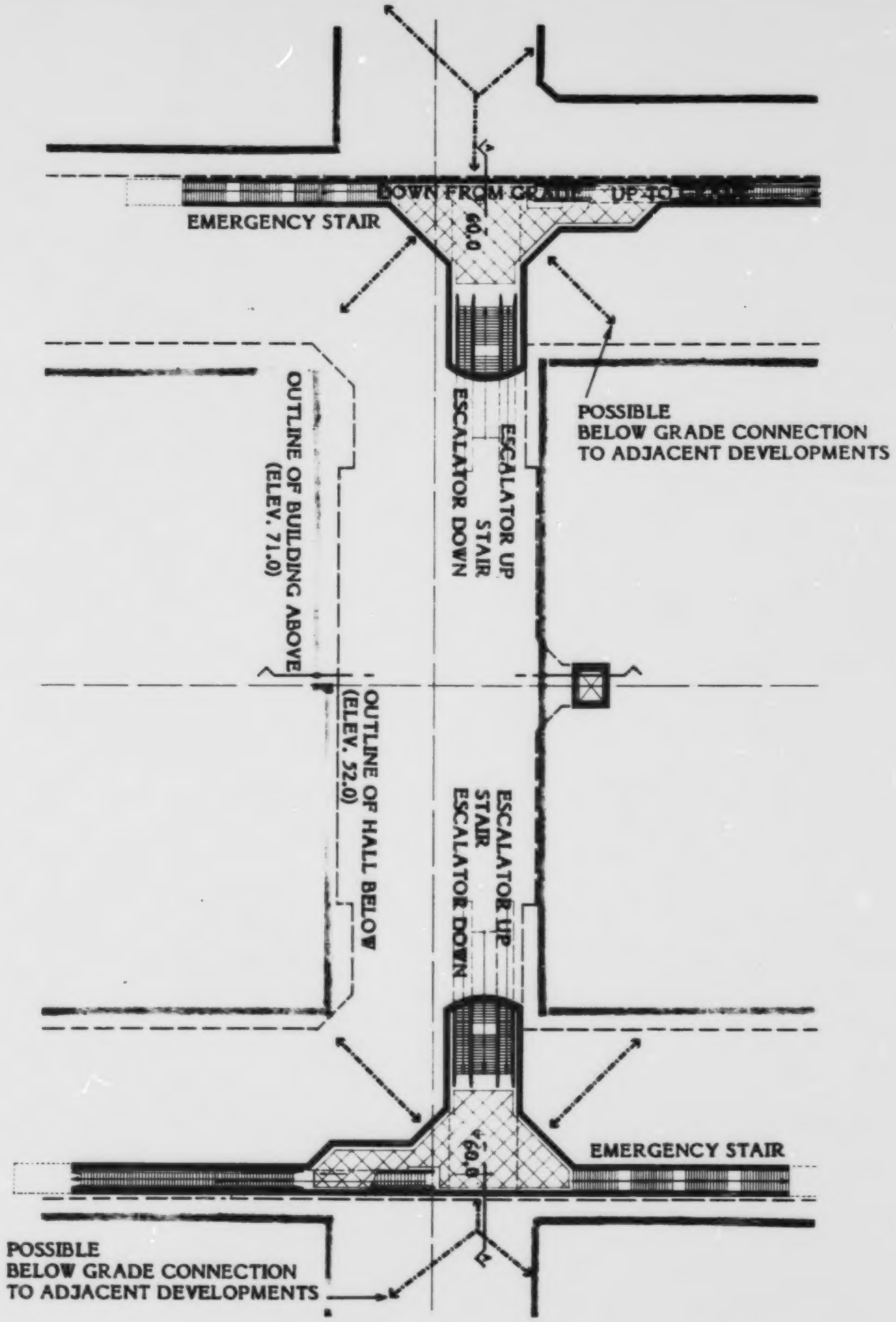
**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**VARIOUS CROSS SECTIONS**

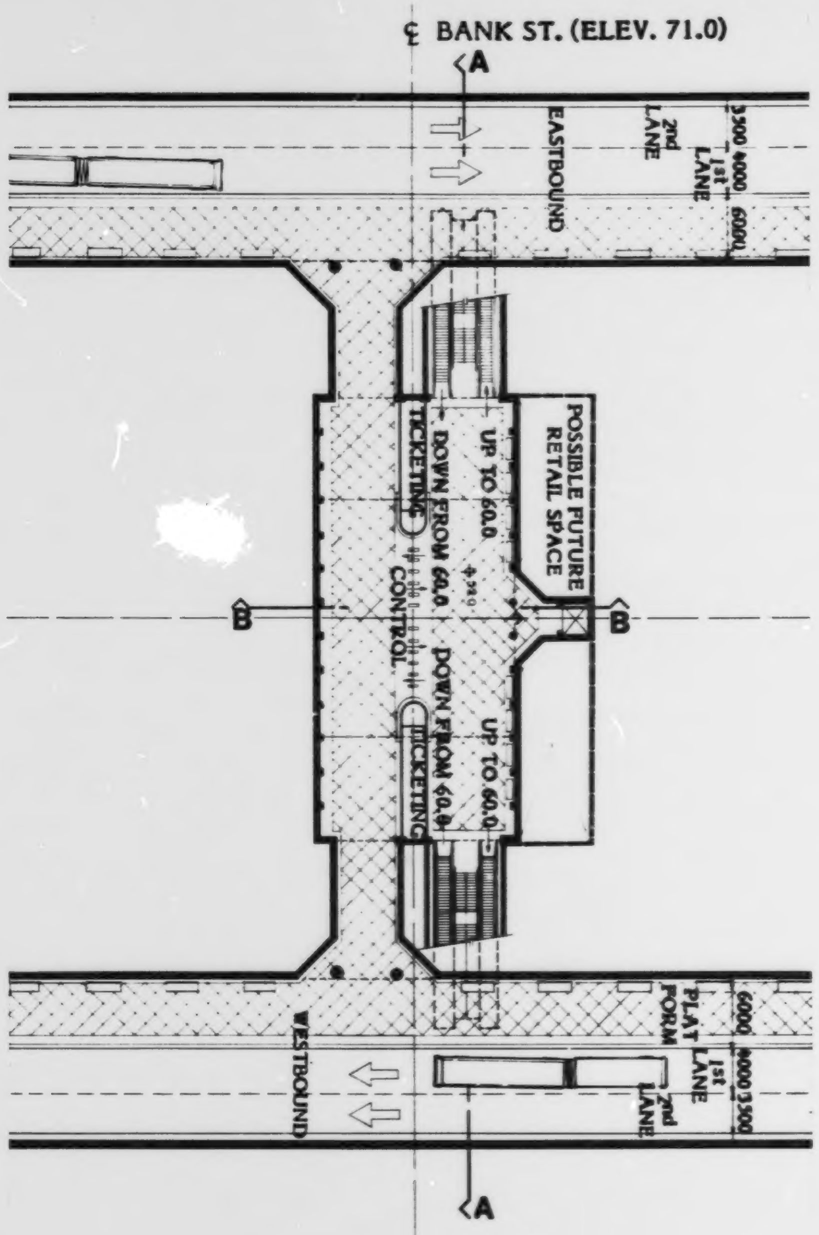
**EXHIBIT 4.4**


EMERGENCY STAIR
ESCALATOR
ALBERT
EASTBOUND TUNNEL
SLATER
WESTBOUND TUNNEL
ESCALATOR
OUTLINE OF TRANSITWAY BELOW (ELEV. 60.0)
EMERGENCY STAIR
BANK

PLAN AT GRADE
ELEV. 71.0


EMERGENCY STAIR
DOWN FROM GRADE
UP TO
60.0
POSSIBLE BELOW GRADE CONNECTION TO ADJACENT DEVELOPMENTS
OUTLINE OF BUILDING ABOVE (ELEV. 71.0)
ESCALATOR DOWN
ESCALATOR UP
STAIR
OUTLINE OF HALL BELOW (ELEV. 52.0)
ESCALATOR UP
STAIR
ESCALATOR DOWN
EMERGENCY STAIR
60.0
POSSIBLE BELOW GRADE CONNECTION TO ADJACENT DEVELOPMENTS

INTERMEDIATE ACCESS LEVEL
ELEV. 60.0

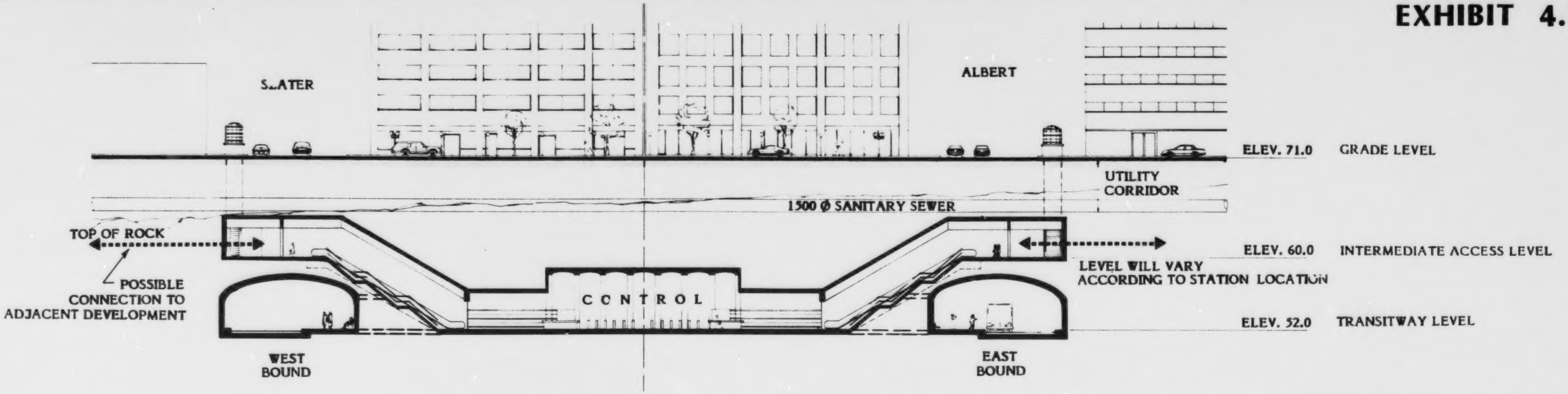

℄ BANK ST. (ELEV. 71.0)
A
EASTBOUND
2nd LANE
1st LANE
3500
4000
6000
POSSIBLE FUTURE RETAIL SPACE
UP TO 60.0
DOWN FROM 60.0
TICKETING
CONTROL
DOWN FROM 60.0
UP TO 60.0
TICKETING
B
B
PLAT FORM
1st LANE
2nd LANE
6000
4000
3500
WESTBOUND
A

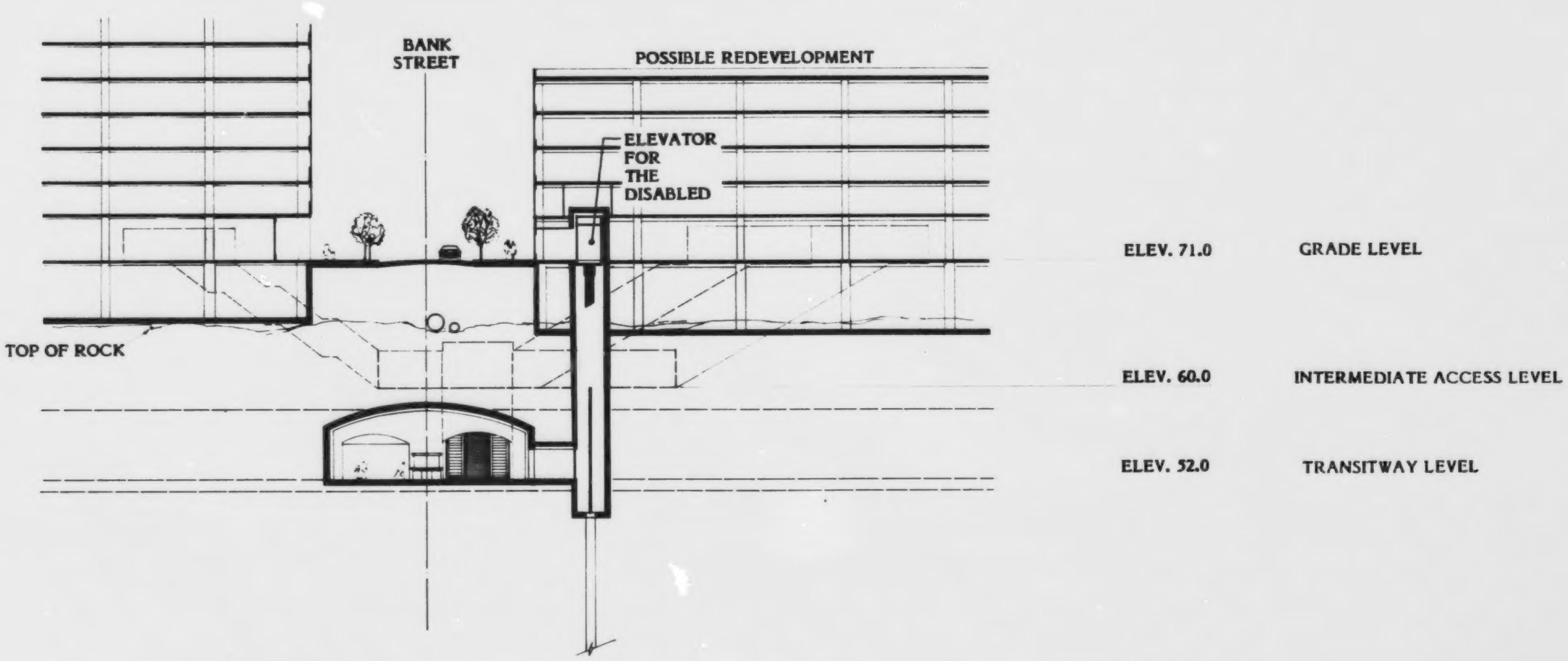
TRANSITWAY LEVEL
ELEV. 52.0

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN** / GRIFFITHS, RANKIN & COOK

**TUNNEL OPTION**
**BANK STREET STATION**

**EXHIBIT 4.5**


SLATER
ALBERT
ELEV. 71.0
GRADE LEVEL
UTILITY CORRIDOR
1500 Ø SANITARY SEWER
TOP OF ROCK
POSSIBLE CONNECTION TO ADJACENT DEVELOPMENT
ELEV. 60.0
INTERMEDIATE ACCESS LEVEL
LEVEL WILL VARY ACCORDING TO STATION LOCATION
CONTROL
ELEV. 52.0
TRANSITWAY LEVEL
WEST BOUND
EAST BOUND


BANK STREET
POSSIBLE REDEVELOPMENT
ELEVATOR FOR THE DISABLED
ELEV. 71.0
GRADE LEVEL
TOP OF ROCK
ELEV. 60.0
INTERMEDIATE ACCESS LEVEL
ELEV. 52.0
TRANSITWAY LEVEL

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
**DELCAN** / GRIFFITHS, RANKIN & COOK

**TUNNEL OPTION**
**BANK STREET STATION**
**SECTION A & B**

Street and Slater Street. The platforms are connected by a tunnel running from Albert Street to Slater Street under the cross street (Metcalfe, Bank, Lyon), in which are located the fare control area and the escalators, stairs and elevator to the street. The station will allow passengers to board or disembark and walk into the control area without a grade change.

If no bus tunnel crossovers were adopted then the doors of the buses would be on the outside, requiring the transit passengers to go up a level before gaining access to the station area located one level above the platforms. This would have complicated station design and transit user access to the stations and increased the cost. It would have depressed the profile of the stations and the transitway.

Street level access to the stations can take place from the north side of Albert Street and south side of Slater Street, via an intermediate level, just below all the utilities and possibly in rock, depending upon the elevation of the rock at that point. There the passengers turn and take the escalator down to the station platform level. The design of the station is flexible in that it can be entered from a number of locations. It allows any form of passenger fare control and also permits pedestrians to utilize the station without entering the fare paid zone. OC Transpo then has the benefit of this flexibility for future fare collection schemes. The station could also be used as a pedestrian link in the Central Area. It may or may not be desirable to encourage the use of the station to accommodate these movements.

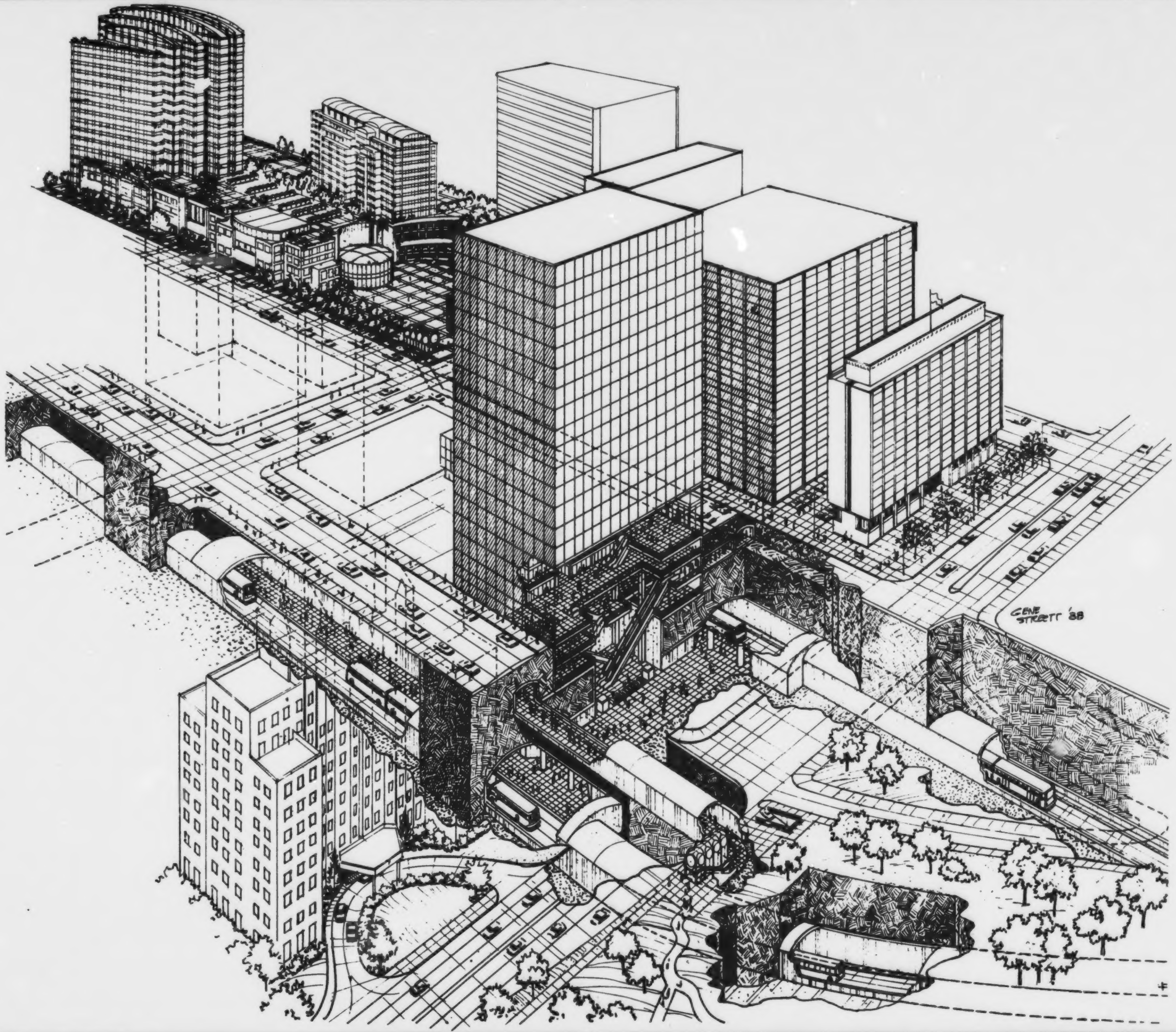
From the intermediate level just below the utilities, options exist to extend pedestrian tunnels along and beneath Albert and Slater Streets, or along the north/south streets to develop a wider network of access points. One such connection could be developed along Albert Street to the Canlands development and another, east under Slater Street to the east side of Elgin Street where pedestrian access would serve the Court House and RMOC Headquarters. These additional access points can be developed over time as the need and Central Area development requires. Pedestrians relate to where the access points from the surface are located. The actual location of the station, and the platforms is not of primary importance as long as they are relatively directly connected to the surface. The proposed arrangement of access points permits flexibility for the future, and more importantly, a direct elevator can be provided to the station level.

The stations can also be provided as part of a mid-block development and be totally integrated into the urban fabric. Typically, it is at such locations that air rights developments occur. Many examples exist in other cities. An excellent opportunity exists for the Metcalfe Station in the property immediatly west of the former National Gallery. This concept is illustrated on **Exhibit 4.6** and it illustrates how pedestrian connections can be extended west to Canlands and east to the east side of Elgin. The proposal is conceptual only but it is illustrative of a development opportunity either on the vacant lot, or a redevelopment of part of the block. Similar opportunities exist at Lyon Street.

### 4.2.4 Construction

There are two standard methods of tunnel construction. The drill and blast technique is well proven and has many advantages in construction scheduling including low start-up time and costs, ability to work multiple headings and flexible material removal arrangements. Against this is the perception of disturbance due to blasting. Advances in the use of explosives have been made so that controlled low shock blasting can be achieved. The alternative is to use a tunnel boring machine (TBM), which is designed to excavate the required diameter hole. This method would produce very little vibration and has been proven to be effective in many projects. It does require a longer set-up period, but once operational, it can work very effectively and efficiently. Drill and blast will still be required for the connecting station sections, ventilation shafts and at the tunnel portals.

**EXHIBIT 4.6**



**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** /HARRY WEESE & ASSOC.

**ARTIST CONCEPT OF A**
**TYPICAL TUNNEL STATION**
**INTEGRATION WITH PRIVATE DEVELOPMENT**

The geology along the route appears to be favourable for the use of a TBM. The RMOC is thus in an enviable position of having both construction techniques as possible contenders, depending on the findings of the functional design and geotechnical studies which must be conducted to confirm geology and the concept designs outlined in this study.

The most important advantage of the tunnel construction technique is that on-street disturbance is very much reduced during the construction period. The entrances to the tunnel at the east end will require surface construction and some traffic rerouting. At the west end, all construction activity would be accommodated in the Lebreton Flats area with little disruption to Central Area activities. Through the Central Area, it is anticipated that the tunnels can be constructed, stations excavated, cross connections between Albert Street and Slater Street prepared, with only limited surface disruption in the immediate vicinity of the pedestrian access structures and ventilation shafts. Activities that will cause disruption, at specific locations, are the construction of the ventilation shafts and the station connections to the surface. If a station is developed off-street in a vacant parcel of land, no disruption to street traffic, utilities or businesses in the Central Area should occur at that station location. This is a considerable benefit as normally the construction activities at a station take the longest time. This attribute of the tunnel option is of significant importance to downtown businesses, transit and vehicular operations.

The construction period for such a major project could be as short as three years but more likely 3.5 to 4 years. The possible adverse effects of street level construction on OC Transpo operations is an important factor to consider. With the tunnel option, very little adverse impact is expected and OC Transpo should be able to maintain service levels compatible with surface operations. The impact of either cut and cover or elevated options on OC Transpo would be very severe and costly to overcome.

There is some uncertainty in the appropriate construction technique to be used east of the Canal. This is because detailed information on geology is not available. It may be that the section from Campus Station to Daly Avenue could be more economically constructed using cut-cover techniques. If this is so, then there would be street level disruption in this area. However, it will be possible to accommodate these construction impacts much more easily than in the Central Area between Elgin Street and Bronson Avenue. A final decision on this aspect will not be possible until later in the design process.

Construction scheduling of the tunnel option is also very flexible because it does not involve much surface disruption. The tunnelling contracts can also be varied to accommodate cash flow availability. This contrasts with the cut/cover and elevated options both of which involve extensive street level impact which exerts pressure to speed up construction and hence accelerate and compress cash flow requirements. Preliminary study indicates that a comfortable construction period would be three and one half years. A possible implementation schedule is shown on **Exhibit 4.7.**

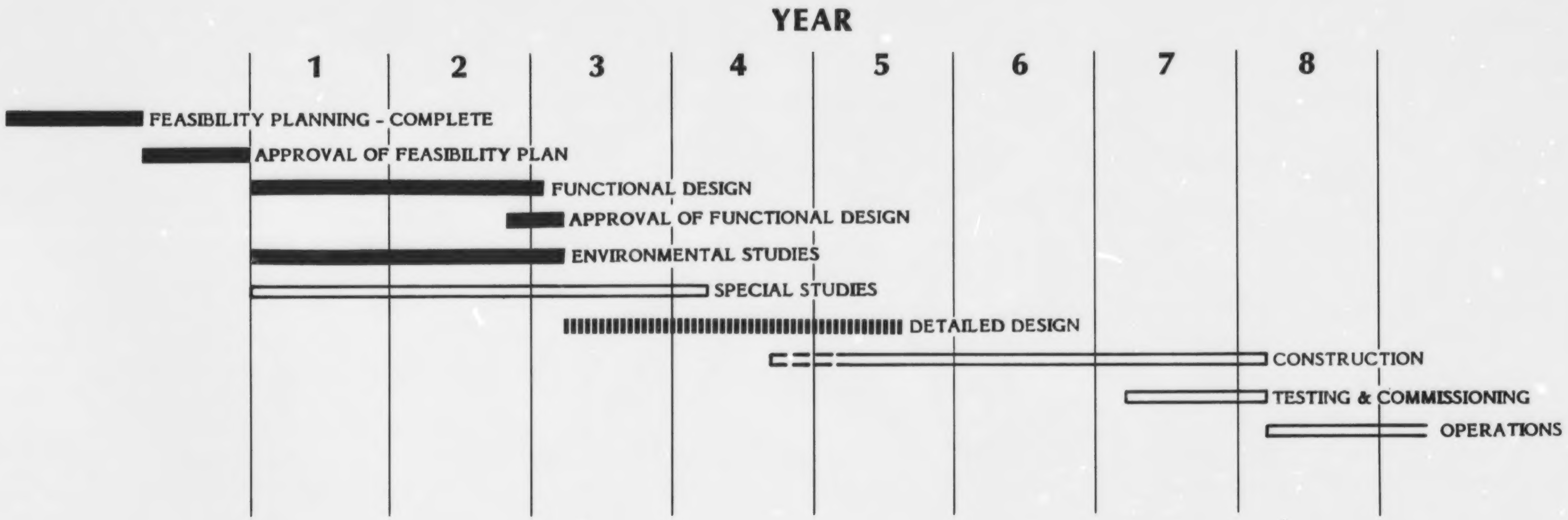
### 4.2.5 Urban Design Integration

The tunnel option presents a series of opportunities to integrate the Transitway into the Central Area in a manner that is supportive of many desirable planning objectives. The best opportunities for urban design integration exist at stations where exciting, yet very functional concepts can be developed. Excellent opportunities exist to provide direct pedestrian-transit passenger flows to a wide section of the Central Area. In addition, with the removal of a large number of the buses from Albert and Slater, and possibly Queen Street, a number of opportunities for roadway developments are possible. Also, opportunities exist in the vicinity of the University of Ottawa to improve the linkages across the existing transitway. **Exhibit 4.8** illustrates some of the urban integration opportunities.

### 4.2.6 Urban Retail/Commercial Impact

Tunnel options will have the lowest level of adverse impact on retail and business in the Central Area. Areas of construction disturbance will be

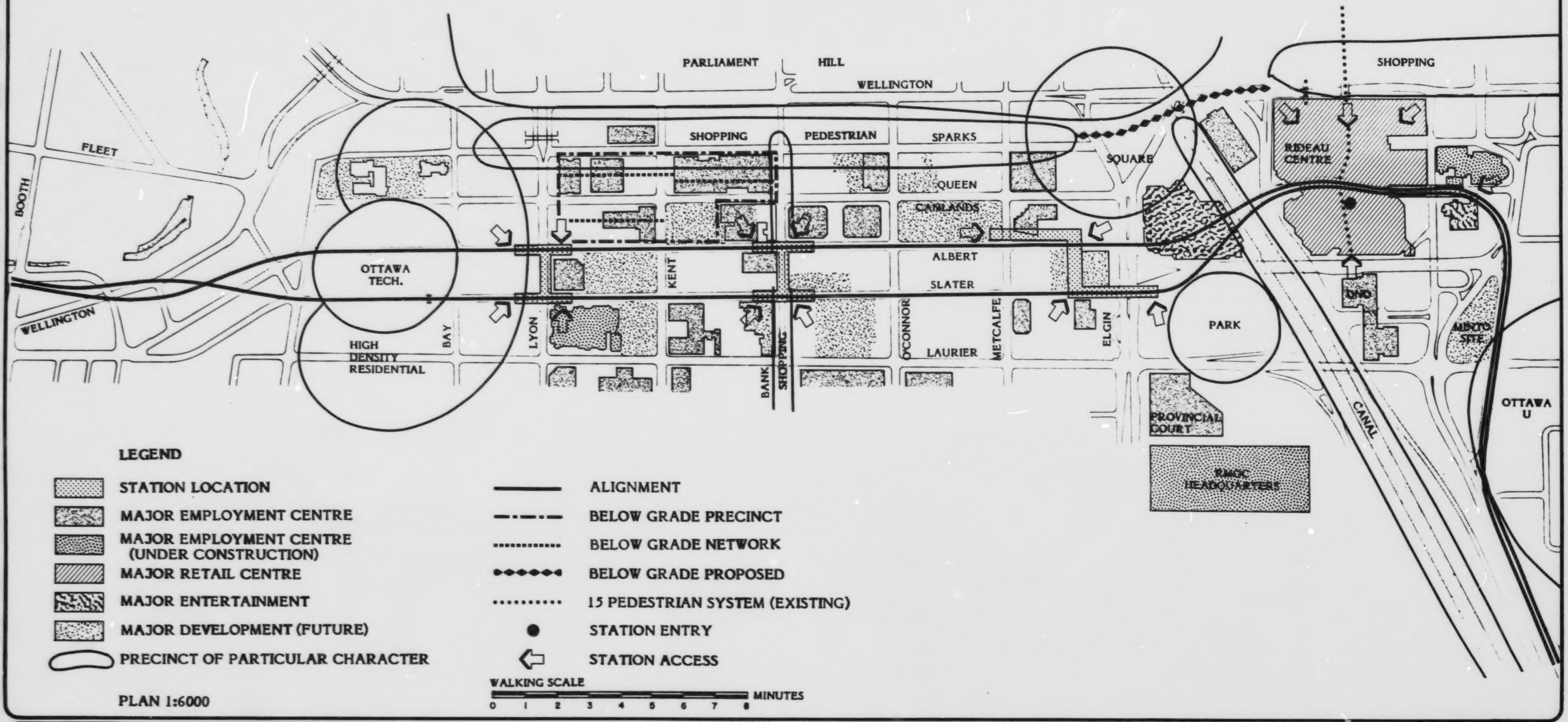
**EXHIBIT 4.7**



REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
**DELCAN**

## POSSIBLE PROJECT SCHEDULE

**EXHIBIT 4.8**


PARLIAMENT
HILL
WELLINGTON
SHOPPING
FLEET
BOOTH
SHOPPING
PEDESTRIAN
SPARKS
SQUARE
RIDEAU CENTRE
QUEEN
CANLANDS
ALBERT
SLATER
OTTAWA TECH.
WELLINGTON
HIGH DENSITY RESIDENTIAL
BAY
LYON
KENT
BANK
SHOPPING
O'CONNOR
LAURIER
METCALFE
ELGIN
PARK
DND
MINTO SITE
OTTAWA U
CANAL
PROVINCIAL COURT
RMOC HEADQUARTERS
LEGEND
STATION LOCATION
MAJOR EMPLOYMENT CENTRE
MAJOR EMPLOYMENT CENTRE (UNDER CONSTRUCTION)
MAJOR RETAIL CENTRE
MAJOR ENTERTAINMENT
MAJOR DEVELOPMENT (FUTURE)
PRECINCT OF PARTICULAR CHARACTER
ALIGNMENT
BELOW GRADE PRECINCT
BELOW GRADE NETWORK
BELOW GRADE PROPOSED
15 PEDESTRIAN SYSTEM (EXISTING)
STATION ENTRY
STATION ACCESS
PLAN 1:6000
WALKING SCALE
0 1 2 3 4 5 6 7 8
MINUTES

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / GRIFFITHS, RANKIN & COOK

**PREFERRED TUNNEL OPTION**
**URBAN INTEGRATION**
**CONCEPT**

limited in scope and time. There will be no residual negative factors with the tunnel option with the possible exception of the tunnel access structures. Any grade-separated option will produce positive benefits in the Central Area in that it will provide an exclusive right-of-way for transit. Elevated and Cut/Cover options will create short-term negative impacts during construction. Furthermore, in the case of the elevated option, long-term negative impacts on the existing and proposed development along the corridor will result.

The most important factor in favour of tunnel options from the retail/commercial viewpoint is that the portion between Bronson Avenue and the Rideau Centre can be constructed with limited street level disruption. Although significant efforts can be made to mitigate the construction impacts, some businesses are very dependent on the street trade, and they may be adversely affected. Extensive efforts can be made to lessen this impact. The Seattle experience provides an excellent model of a pro-active program to assist business and commercial interests in construction areas.

### 4.2.7 Vehicle Technology

It is recommended that articulated buses be used on the Transitway and that the majority of these buses be non-diesel powered. Available technologies include several alternative fuel buses including natural gas and dual mode electric/diesel powered buses. While existing diesel technology is not recommended because of the need to create a high quality passenger waiting area at the stations, significant improvements are planned for diesel engines, by 1991 and 1994, in response to the United States Environmental Protection Agency mandated reduction in diesel emissions. These improvements will be available before the tunnel is operational. They will result in a very much improved environmentally sensitive power plant for buses.

The use of natural gas vehicles is also an option. OC Transpo is engaged in a demonstration program of this technology with others, including Toronto Transit Commission, Ontario Research Corporation and the Ministry of Transportation, Ontario. In the seven to nine years before operations can begin on the grade separated Transitway, other fuel/vehicle developments should be explored such as diesel/battery or dual-mode diesel/electric vehicles similar to Seattle's new fleet. Additional fleet planning will be required in the next few years to develop an appropriate program to satisfy surface bus needs as well as properly position the OC Transpo fleet at opening date.

The geometrics of the tunnel are compatible with rail technology.

### 4.2.8 Ventilation/Fume Dispersal

The ventilation system proposed must be designed to have a capacity to respond to a fire in the tunnel and thus, is more than adequate to accommodate the needs of the normal vehicle generated air quality requirements. The proposed system introduces fresh air at the stations and exhausts it between stations. Ventilation structures need to be built along the right-of-way and preliminary examination of the requirements indicates that these can be appropriately located. Special fume dispersal - wind tunnel studies should be carried out to determine the best location for these structures, given the physical layout of the downtown and the ventilation requirements. Architectural and landscape design studies will be required to integrate these structures into the Central Area landscape, or incorporate them into new or existing buildings and exhaust the tunnel air at appropriate locations and elevations in the downtown.

### 4.2.9 Noise and Vibration Studies

An extensive investigation of noise and vibration effects was conducted to assess the possible impacts and to identify design guidelines for ongoing work. The results of the studies indicate that for the preferred tunnel option, no significant problems that cannot be overcome with design studies are apparent. Design guidelines for stations were identified that would help to improve the transit passenger environment within the station area.

With respect to the possible impact of vibration, it is estimated that with rubber tired buses and 10 m of rock between the tunnel structure and the NAC or other buildings, no perception of ground borne vibration will be evident. Provisions can be made in the final design to install a special "floating slab" floor in sensitive locations if felt necessary. This technique is used for rail transit.

### 4.2.10 Operations

The grade separated options would all provide very significant operational improvements and savings. The surface transit operation would continue to be faced with increasing competition for road space and intersection capacity. The grade separated Transitway would be able to provide a significant improvement (two times) in travel speed, level of service and service reliability. The operating flexibility provided by the bus passing lanes at stations is important in the event of bus breakdown. The operating strategies tested with the Central Area Transitway Simulation Model (CATSIM) indicate that peak hour bus passenger demands beyond 2014 can be accommodated. In the longer term, it is possible that other sections of the transitway could be developed that would allow passengers not destined to the CBD to bypass it, thus freeing up capacity for the CBD destined passengers.

An advance bus passenger information system operating on a dynamic basis will be required to assist passengers, especially in peak periods, to queue up at the right location in the stations. The development of this passenger aide is part of current OC Transpo plans. This will minimize boarding times during peak periods and assist in achieving high boarding rates. Proof of payment or full fare control can be utilized at the discretion of the operator.

One of the most attractive features of the tunnel option is that it can be implemented with very little disruption to the existing surface bus operations which must continue to function and accommodate the heavy bus volumes during the implementation period.

### 4.2.11 Comparative Capital Costs

A major factor in the evaluation of the three options is their relative capital costs. The estimating procedure has consequently been structured so as to give a high degree of confidence to comparative costs. In order to prepare an accurate construction cost estimate, it is necessary to have in addition to a clear scope of work, a firm implementation schedule as inflation plays a key role in the actual cost of any project. As the determination of the precise scope and a final schedule is outside the scope of this feasibility study and as the timing of construction is to a great extent dependent on funding from levels of government other than the Regional Municipality, only a base year (1988) comparison can be made. Such analysis is suitable for comparing the relative costs between different options but is not suitable for financial budgeting purposes.

The comparative cost analysis was based on conceptual drawings with only limited details of the final product and the sub-surface conditions along the route. Risk factors were applied to each element to allow for cost variations which could arise due to the need for greater quantities of material, more complex structures or more costly equipment and material than can be foreseen at the concept stage. A contingency factor was also applied to each major element of the work to allow for those items of work not identified at the concept stage.

The comparative cost analysis recognized the following factors:

- All the work elements in a particular part of the project, i.e., station, or tunnel section, were summed up and an overall risk associated with that item applied.

- In other cases, lump sum estimates were used, again consistent with current practice and knowledge. A risk factor was assessed.
- Unit costs and overall costs were reviewed with various team members for reasonableness.
- Where quantities could be estimated, they were calculated and unit rates consistent with that element were used. A risk factor was applied depending upon the degree of uncertainty associated with that work.
- Property costs were estimated by professional appraisers.
- Costs of construction in Seattle were reviewed to identify order of magnitude costs of project management and engineering.

The following Table 4.1 sets out the comparative costs. For the three options. The recommended tunnel option is 20% less expensive than the cut and cover option, and 10% more expensive than the elevated option. The elevated option had many technical, operational and environmental constraints. It is not considered a viable option.

Future work is necessary to investigate the availability of funds and to determine their impact on the project cost. Several possible scheduling/funding alternatives must be examined in order to arrive at an escalated capital cost which can then be utilized for financial planning purposes. This must be done in conjunction with the functional design before a "baseline budget" can be established.

**TABLE 4.1**

**RELATIVE COSTS**
**(1988) OF THE THREE OPTIONS**

| | |
|---|---|
| **Tunnel** | **Recommended** |
| **Cut and Cover** | **+20%** |
| **Elevated** | **-10%** |

### 4.2.12 Other Costs

In addition to the capital costs, there are other potential costs of implementing a grade separated transitway.

- disruption costs to the retail and commercial businesses along the route over the 3 to 4 year period of the construction activity: this will be significantly more for cut and cover and elevated;
- impacts on assessment values and taxes on buildings affected along the route: this is estimated to be a $4 million per year cost associated with the elevated option;
- operational costs to OC Transpo to accommodate the detours and street congestion through the Central Area if the surface streets were affected by Transitway construction over 3 to 4 years as would be the case with cut and cover or elevated options: this cost is estimated to be $20 million for reduced speed of operation and increased route length;
- operational costs to all other traffic during construction over 3 to 4 years: this is estimated to be $5 million with the cut-cover and elevated options;
- time delay costs incurred by transit passengers and all other vehicular passengers if extensive street construction were to be required as would be the case with the cut-cover and elevated options. This is estimated to be $50 million over three to four years.

All these costs are difficult to quantify but all act to favour the tunnel option over the cut/cover and elevated options. An approximate estimate of the additional costs due to cut-cover or elevated surface disruption during construction would be $80 million.

Another significant benefit of the tunnel option, and in particular, early construction of the tunnel option is that the transit system would be operationally protected from future roadway and bridge construction required in the Central Area. These facilities, Bronson-Portage, Laurier, perhaps MacKenzie King Bridge, will all require considerable surface disruption, and if the tunnel system were in place, transit could operate without surface disruption impact and perhaps become the preferred alternative to a larger number of travellers to and from the Central Area. This option also presents some opportunities for realignment of bus routes in the Central Area that may remove surface OC Transpo routes west of Bank Street. MacKenzie King Bridge could be rebuilt without disruption to transit and it would not have to accommodate the large bus volumes it currently handles.

### 4.3 Economic Analyses

The economic analysis performed for the project used the improved surface operation implemented in 1987 through the Central Area as a base case. One of the key assumptions in all economic analyses in this project is the estimated future speed of surface traffic. For this analysis, surface operations were expected to slow down from 14 km/h in 1987 to 10 km/h by 2000. This is in comparison to the bus speeds on the Transitway that will be at 25 to 30 km/h through the Central Area, including allowances for stopping and boarding passengers. Beyond 2000 the surface speeds of buses and other traffic on Albert and Slater Streets can be assumed to remain at 10 km/h, or decline to 5 km/h in the last 5 years of the analysis period 2009 to 2014. Benefits for both assumptions were tested.

The economic analysis estimated the costs on a year-by-year basis for the possible surface option and also for each of the three grade separated options. The difference between the various costs for the surface option and the grade separated options was identified as the benefit. The various costs that were examined included:

- cost of annual peak period bus operations;
- cost of annual off-peak period bus operation;
- capital cost of extra bus requirements to accommodate continued surface operation;
- capital cost of building the Central Area Transitway;
- annual cost of time savings to transit users in peak periods;
- annual cost of time savings to transit users in off-peak;
- annual vehicle operating cost savings to other traffic as a result of removal of Transitway buses from Albert Street, Slater Street and Queen Street;
- annual vehicle person time savings to other traffic as a result of removal of Transitway buses from Albert Street, Slater Street and Queen Street.

In the analysis, all of the benefits are related to some aspect of time savings. This is reasonable, for if time were not important, nobody would worry about congestion or the need to add capacity, roadway or transit. The value of time for the bus operation is very well established through exhaustive records at OC Transpo. User time is more subjective as it involves the concept of the value of a person's time. In these analyses, the value of peak period time selected conformed to the value of time used in highway/freeway economic analysis by MTO. For off-peak time savings, one-half the minimum hourly wage rate was used. A typical transit passenger would realize a time savings of at least 40 hours per year due to the construction of the tunnel. Vehicle operating costs were estimated using data from the Canadian Automobile Association. No commercial vehicle benefits were included.

All grade separated Transitway options indicate a positive net benefit over continued surface operation. The economic analysis covered a 20 year framework from the commencement of operations (1997). The base case - surface operation - is a bit theoretical beyond the early 2000's as it is not possible at that time to accomomdate the expected transit bus volumes on the surface within acceptable transit service levels. One important objective was to preserve, if not improve the transit service levels in the future if it is planned to maintain or improve the high modal splits to the Central Area now enjoyed by transit. Beyond the year 2000, continued surface transit operations in the Central Area would be expected to suffer deterioration of service levels, possibly lose passengers and be forced to operate on additional streets in the Central Area because Albert and Slater would not be able to accommodate any more buses.

The benefits associated with the grade separated tunnel option are composed of three groups and are derived by comparing the continued surface operation to the tunnel operation.

- Transit bus operations
    - savings in operating costs of buses during peak and off peak.
- Transit Users
    - savings in travel time during peak and off peak, valued at $8.00 per hour in peak, and $2.25 per hour in off peak.
- Non-Transit Traffic
    - savings to other vehicular traffic in the Central Area that receive benefit by virtue of the removal of the Transitway buses from Albert-Slater Streets.

There is an immediate benefit of over $20 million per year with the grade separated option. The magnitude of this benefit is very sensitive to the vehicle operating speeds in the Central Area but the benefits are still very real. Perhaps most significant is the fact that OC Transpo would be on the verge of rapidly increasing costs of operation with further congestion in the Central Area. It should come as no surprise to relate OC Transpo operating costs to speed. A 10 percent reduction in system average speed equates to over $10 million dollars in annual operating cost savings.

In subsequent years, transit operational savings increase further gradually. The transit user benefit in time savings is substantial and is composed of peak and off peak time savings. Peak savings constitute the majority of the savings.

Other traffic benefits are estimated to accrue from the better surface operations that will be available to all traffic, given the removal of the Transitway buses from Albert and Slater. In effect, two new arterial lanes of capacity will have been introduced into the Central Area.

If one were to examine the cumulative effect of the costs and benefits, there would be an initial deficit due to the large upfront capital costs, but these costs would be gradually offset by the continuing benefits. If the capital costs are similar to the Seattle experience and if the project is operational by 1997, then the operational cost savings will offset the capital costs in 10 to 15 years, and from then on the Region and its Central Area will continue to realize the benefits of the initial investment. These benefits would not include any provision for induced benefit to development due to the availability of a reliable, fast, efficient transit service.

There are other indirect benefits that have not been quanitified or included but which are nevertheless real. These benefits include:

- enhanced Central Area attractiveness to employees due to the availability of a reliable, fast public transport system covering the entire region. This increases the labour pool for all employers;
- enhanced development opportunities due to the presence of the "final" Transitway link through the Central Area, and the possibility of developments tying in to stations;

- opportunities to implement the Central Area Transitway with little surface street disruption. This produces real benefits to transit, motorists, pedestrians, merchants and business people;
- opportunities to insulate the transit system from congestion related to the implementation of major Central Area roadworks required in the short- to mid-term;
- opportunities to reclaim some street surface along Albert and Slater for street enhancement purposes;
- opportunities to use the station access network to widen the access system to the Transitway and direct pedestrian flows to accomplish other transportation and development objectives;
- opportunities to maximize use of investment in the rest of the Transitway system.

### 4.4 Future Work

The purpose of this feasibility study was to determine if the Transitway could be grade separated and what the preferred option would be in terms of alignment, profile and form.

Prior to any decision to proceed with the design and implementation of the project, additional work is required. This would consist of the undertaking of a functional design and the preparation of an Environmental Assessment. These areas of further work would include the following:

a) Functional Design

This work is required to define the project scope, to establish an implementation schedule and to develop the baseline budget. To support the functional design efforts, special studies will be required in the following areas:

- Geotechnical Investigations and Materials Testing
- Field Surveys
- Fume Dispersal Ventilation Studies
- Development of Detailed Design Standards
- Architectural Studies for the Stations and Tunnel Portals
- Construction Strategy and Scheduling Options

b) Environmental Assessment

In conformance with the Act, certain prescribed procedures must be followed for a project of this magnitude. A number of these requirements may have already been completed as a result of recent RMOC studies and this study. The remaining work to be done to comply with the MOE requirements will be determined in discussions with the MOE, and a program to complete this work outlined and coordinated with the functional design studies.

In parallel, OC Transpo will need to conduct or participate in operational studies to refine the operating procedures for the grade separated facility. In addition, fleet planning studies, as well as vehicle operating and maintenance studies for the selected vehicle/fuel combination will need to be undertaken. These studies will be integrated with the ventilation studies as the vehicle technology, fuel choice, operations strategy and ventilation concept are all inter-related.

Approximately two years will be required to complete the functional design and prepare the Environmental Assessment Study. Only at this time will a baseline budget have been determined, enabling the Regional Municipality to be in a position to take a decision as to whether to proceed with final design and project implementation.

# CHAPTER 5

# 5.0 ELEVATED TRANSITWAY OPTION

## 5.1 Introduction

In this chapter the concept development for the Elevated option is outlined. The technical analysis involved in developing the concept is described and a description of the process used to identify the preferred elevated option is given. The preferred elevated option was refined for comparison with the other grade separated options. A section on the complementary station concept development and construction sequencing preceeds a section on the operations implications of the elevated transitway. The summary and conclusions of the analysis of the elevated transitway option complete this chapter.

## 5.2 Elevated Option Concept Development

### 5.2.1 Preliminary Concepts

With this concept, the Transitway would, after leaving Campus Station, climb up to a structure with minimum 4.5 m clearance and cross through the area east of the Canal with a station located to serve Rideau Centre and then continue westward across Elgin and down one or more of the Central Area streets and, finally, exit west of Bronson Avenue over or through the escarpment and approach Lebreton Station.

A number of alignments as shown on **Exhibit 5.1** were developed in each of the three main sections of the route, i.e., east of the Canal, Canal to Bronson Avenue and west of Bronson Avenue. In each of these three areas, a number of very different constraints was evident which affected the geometrics, curvature and grades. The alignments developed included a split Transitway with eastbound on one street and westbound on another street, as well as a double stacked option. **Exhibit 5.2** illustrates in a conceptual manner some of these possibilities.

Preliminary structural evaluation was conducted to establish the standard spans for the structure and the cross-sections required for the basic Transitway, as well as for the elevated stations. Preliminary engineering studies of the profile and grades were required to assess the opportunities to cross over or under the proposed Bronson-Portage roadway connection. The development of an acceptable profile and alignment for the elevated option was complicated by the requirements that were fed into the iterative process by the Urban Design Team members.

### 5.2.2 Preliminary Screening of Initial Concept

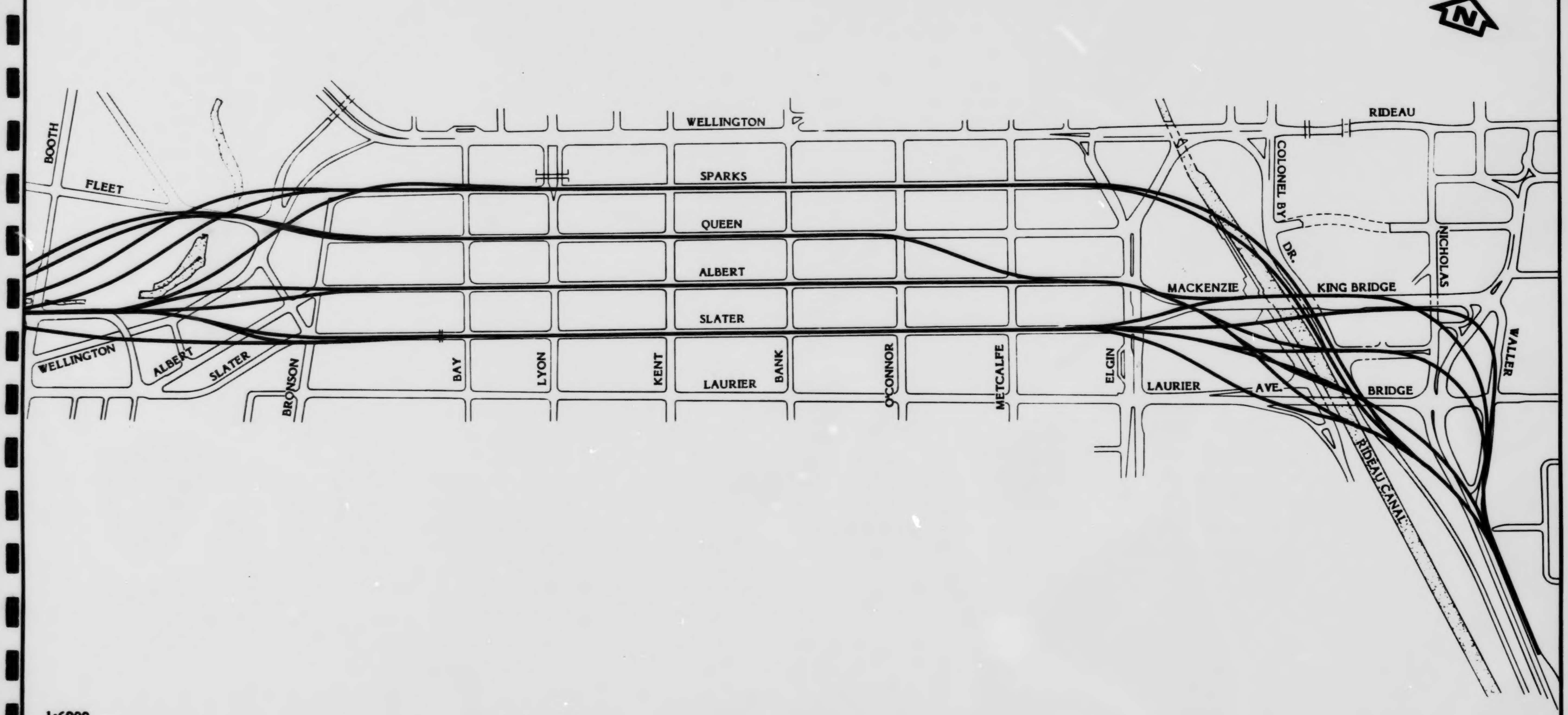
The preliminary screening and evaluation with respect to the urban design impact of the alignments can be summarized as follows:

A comprehensive collection of data on the study area was assembled and described on study area base maps. Information on zoning, heritage buildings, planned and proposed developments, etc., was gathered and plotted. All these factors were important in assessing the constraints and opportunities for the grade separated options through the downtown. A complete appreciation of the visual elements in the study area was developed. This was based on the personal knowledge of the resident team members and documented. A set of slides was prepared, along with photos that were used in the detailed assessment for testing various obstructions to views from different locations.

As can be expected, in the Nation's Capital, there are a number of major environmental constraints, primarily related to parks, open space, monuments and major buildings. Because the elevated option would probably have the greatest physical impact, it was examined in detail.

The alignments shown in **Exhibit 5.1** were presented to the Urban Design Team for review. In general, it was very difficult to identify any acceptable alignments. The consensus was that if an elevated alignment was to be further studied, then the best of the options would be on Slater Street,

**EXHIBIT 5.1**


N
BOOTH
FLEET
WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
RIDEAU
COLONEL BY DR.
NICHOLAS
MACKENZIE
KING BRIDGE
WALLER
LAURIER AVE. BRIDGE
RIDEAU CANAL
WELLINGTON
ALBERT
SLATER
BRONSON
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN

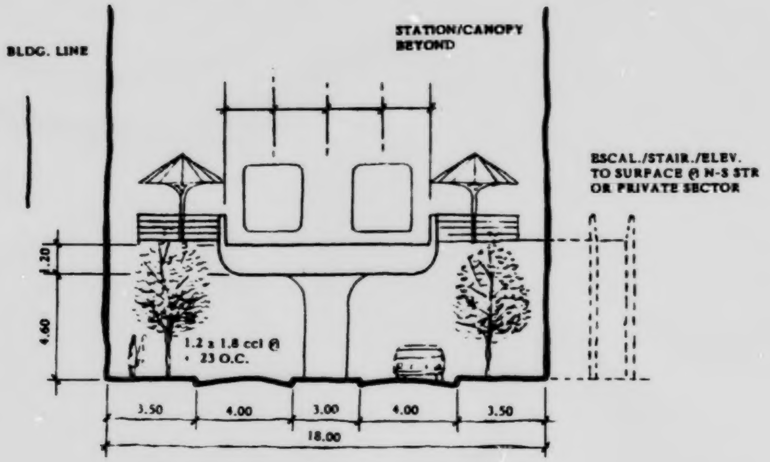
1:6000

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

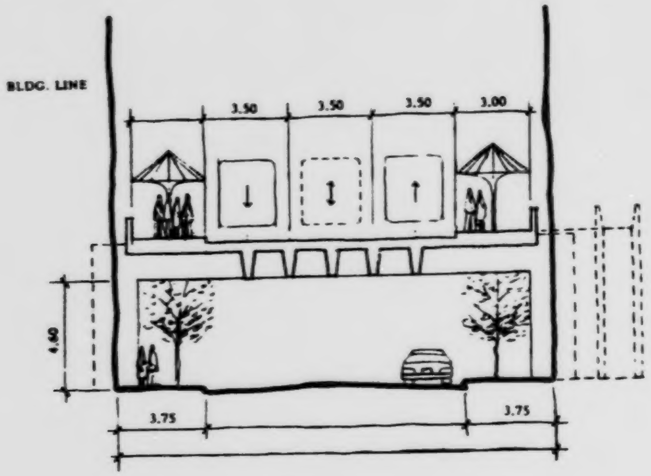
**DELCAN**

## FAMILY OF ELEVATED ALTERNATIVES INVESTIGATED

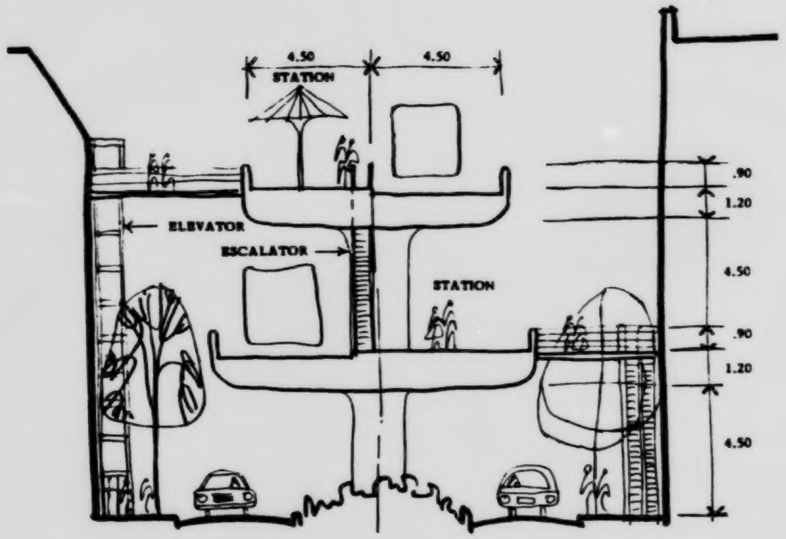
**EXHIBIT 5.2**


BLDG. LINE
STATION/CANOPY BEYOND
ESCAL./STAIR./ELEV. TO SURFACE @ N-S STR OR PRIVATE SECTOR
1.20
4.60
1.2 x 1.8 cci @ 23 O.C.
3.50
4.00
3.00
4.00
3.50
18.00

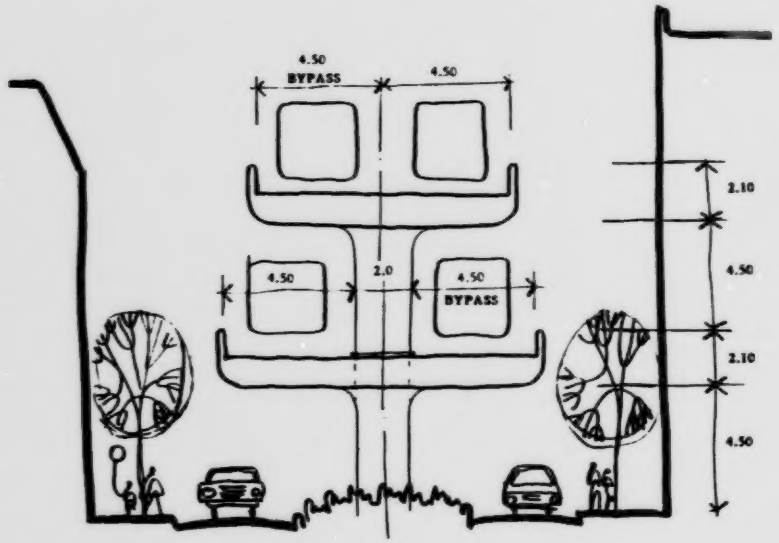
**DESIGN ELEMENTS**
ELEVATED GUIDEWAY
. ELEVATED STATION
. STATION CANOPY
. SINGLE COLUMN SUPPORT
. ESCALATOR/STAIR TO STREET
.POSSIBLE ACCESS TO PRIVATE SECTOR
. STREET MEDIAN


BLDG. LINE
3.50
3.50
3.50
3.00
4.50
3.75
3.75

**DESIGN ELEMENTS**
. ELEVATED GUIDEWAY
. ELEVATED STATION
STATION CANOPY
. DOUBLE COLUMN SUPPORT
(COLUMN AT SIDEWALK/BUILDING)
. ESCALATOR/STAIR TO STREET
POSSIBLE ACCESS TO PRIVATE SECTOR


4.50
STATION
4.50
ELEVATOR
ESCALATOR
STATION
.90
1.20
4.50
.90
1.20
4.50

**DESIGN ELEMENTS**
TWO LEVEL ELEVATED GUIDEWAY
VERTICALLY OFFSET ELEVATED STATION
STATION CANOPY SUPPORT
SINGLE COLUMN
. ACCESS TO PRIVATE SECTOR
ESCALATOR/STAIR TO STREET
. ELEVATOR TO STREET
. ESCALATOR/STAIR FROM PLATFORM TO PLATFORM


4.50
BYPASS
4.50
4.50
2.0
4.50
BYPASS
2.10
4.50
2.10
4.50

**DESIGN ELEMENTS**
. TWO LEVEL ELEVATED GUIDEWAY
. SINGLE COLUMN
. STREET MEDIAN

**PRELIMINARY DESIGN STUDIES**

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN** / GRIFFITHS, RANKIN & COOK / HARRY WEESE & ASSOCIATES

## ALTERNATIVE ELEVATED CONCEPTS

parallel to the Mackenzie King Bridge (at the existing deck level), and on Nicholas Street. This alignment was the nearest to the downtown, lowest in elevation, and appeared to have the least environmental impact, although the impact was still judged to be severe.

The following observations regarding the various elevated alternatives were noted by the design team, and were given weight in the process of eliminating various alignments from further consideration. The observations are presented from east to west.

### 5.2.2.1 Area East of Elgin Street

From the viewpoint of urban design impact, all elevated options present serious problems especially from Elgin Street to the east end of the MacKenzie King Bridge. An alignment on Laurier Avenue is likely to be the least damaging in terms of visual impact, but was considered to be too far south to serve the core area adequately. All above ground options present severe problems in terms of visual intrusion in this area, especially because of the views to Parliament. All elevated crossings of Confederation Park, and links to the Campus Station via the banks of the Rideau Canal will cause severe damage to the open space. The alignment which follows the east side of the Canal, crossing the north face of the National Arts Centre to Sparks Street via Confederation Square, should not be pursued from an urban design viewpoint. The "least unacceptable" link from Elgin Street to the Campus Station is via MacKenzie King Bridge at the same level as the bridge.

It was felt that the MacKenzie King Bridge and Laurier Bridge provided the only possible east/west alternatives, east of Elgin. Three alternatives are identified for MacKenzie King Bridge corridor. Because a station is needed, more than two lanes of width are required.

(a) Buses elevated above the bridge. This is the most obtrusive solution and was rejected because of its detrimental impact on the views to Parliament Hill from the south.

(b) Capacity of the bridge for regular traffic reduced to provide exclusive bus lanes. This is also in conflict with the desire to retain all existing east/west vehicular capacity, and the fact that more than two lanes would be required.

(c) Bridge widened to accommodate additional bus lanes. The impact on the Rideau Centre and DND building will be severe and may be impractical.

The alignments from Campus station to the MacKenzie King Bridge corridor cause a conflict with the Minto site. Alternatives that allow an improved pedestrian precinct to be developed with good connections to the Rideau Centre would be preferable. The Laurier corridor was dropped because it was not possible to service the Rideau Centre area with links to the Market area adequately.

### 5.2.2.2 Elgin Street Crossing

MacKenzie/Slater link is preferred because of the more compatible grade changes for buses travelling at bridge level onto an elevated Slater alignment. This option allows greater opportunities for urban design to minimize the impact at this most critical point to develop a station to serve the Rideau Centre area.

### 5.2.2.3 Elgin Street to Bronson Avenue

Comments on the various streets that were considered by the Team are summarized below:

Sparks Street Alignment - This route is not recommended because of its visual intrusion. It blocks critical views north to Parliament Hill, and it has a significant impact on Confederation Square, besides the impact along Sparks Street itself.

Queen Street Alignment - This alignment is not recommended because of impact on the area around the National Arts Centre, Canlands and Christ Church Anglican Cathedral.

Albert Street Alignment - Apart from difficulties at the Elgin/MacKenzie intersection, this alignment is generally acceptable from Elgin to Bay. From Bay to Bronson there is negative impact on heritage buildings and the main facade of Ottawa Technical High School. There are opportunities for the integration of stations along this route.

Slater Street Alignment - This alignment works best at the difficult Elgin Street/Mackenzie intersection. Visual intrusions viz views to the north are minimized by southern location. No problems with heritage buildings. Reasonably good opportunities to integrate stations. The Technical High School bridge would have to be removed or rebuilt. The Bronson/Booth connection should be located as far south as possible to reduce impact on the pumping station.

### 5.2.3 Selection of Elevated Option

After detailed review of the alignments, and noting the main observations previously set out, it was the Team's opinion that only two alignments had sufficient potential to be examined in greater depth. These were:

(a) Albert Street via the MacKenzie King Bridge;
(b) Slater Street via the MacKenzie King Bridge.

Of these, the Slater Street alignment was preferred since it has the least objectionable impacts.

As a result of this first screening, an alignment was developed that appeared to be technically achievable although it did not satisfy all of the other urban design requirements. This alignment is illustrated on **Exhibit 5.3.** It contained the following technical issues that were addressed in the Phase II investigations.

- how to pass through the northern portion of the DND building at the elevation of the MacKenzie King Bridge;
- how to develop a narrow Transitway cross-section that would carry the buses but allow appropriate fire department access to buildings along the street;
- how to cross the proposed Bronson-Portage facility and achieve acceptable grades to reach the proposed Lebreton station.

The preferred elevated alignment was subjected to a detailed urban design investigation to identify where it could be accommodated and whether the constraints could be overcome with good urban and facility design. A number of graphic illustrations were prepared to obtain an appreciation of the potential urban impact, to provide other team members with a visual picture of what the facility could look like, and to assist in developing estimates of impacts on property and on retail business in the corridor.

## 5.3 Refinement of Alignment for Preferred Elevated Option

The selected alignment for the Elevated Option is shown on **Exhibit 5.3.** There were two alternatives arising out of the Phase I work. One was to cross over the Rideau Canal by double decking the MacKenzie King Bridge and essentially operate the Transitway one level above the existing bridge. The existing bridge would have to be reconstructed to accommodate this alternative. The second alternative involved an alignment to the immediate south of the MacKenzie King Bridge which passed through the northernmost portion of the National Defence building. This second alternative was chosen because the elevation of the Transitway bridge west of the Canal and over Elgin Street could be kept as low as possible in order to minimize the visual impact. This feature was later compromised due to the height of the proposed station at Metcalfe Street. The alignment then went down Slater Street from Elgin to Lyon Street. After leaving Lyon Station, the Transitway moves south into the playing fields of the Ottawa Technical High School and westward over the Bronson-Portage connection and out into the Lebreton Flats, over Booth Street to rejoin the Transitway in the vicinity of Preston Street.

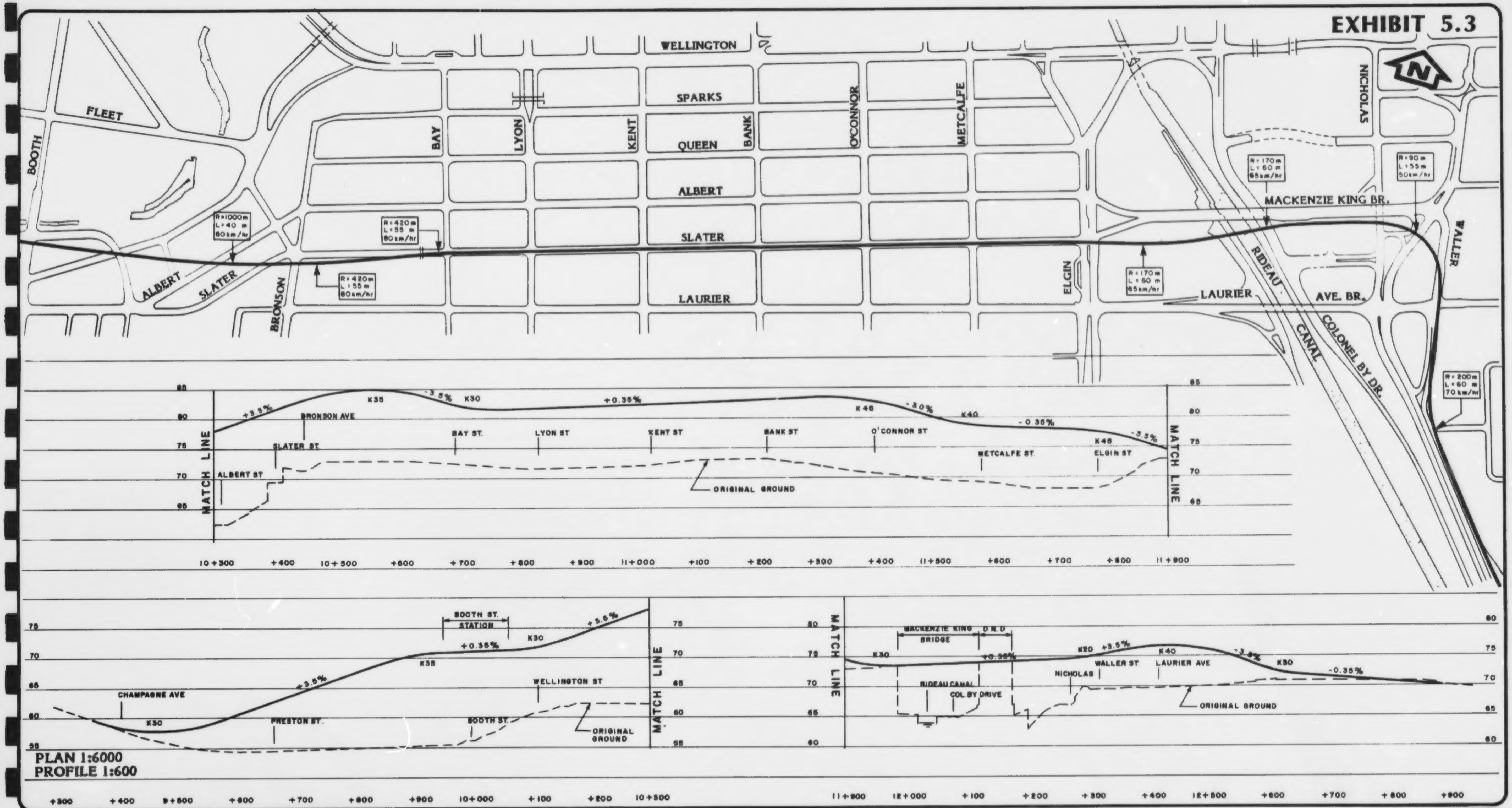
## 5.4 Profile of the Preferred Elevated Option

This section identifies a number of the implications associated with an elevated Transitway profile along Slater Street through the downtown area. The profile of the elevated option is also illustrated on **Exhibit 5.3.**

Earlier investigation indicated that if a truly elevated route were to be constructed, it would overpass the entire Bronson-Portage roadway complex. This would create a significant visual environmental impact. In an attempt to reduce this impact, investigation introduced a profile in the Bronson Avenue area which closely matched the existing ground levels.

The profile transition from the existing at-grade condition at the west end of the Lebreton Flats to an elevated condition at Booth Street would permit

**EXHIBIT 5.3**


N
WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
FLEET
BOOTH
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
NICHOLAS
WALLER
BRONSON
ALBERT
SLATER
MACKENZIE KING BR.
LAURIER AVE. BR.
RIDEAU CANAL
COLONEL BY DR.
R=1000m L=40 m 80km/hr
R=420m L=55 m 80km/hr
R=420m L=55 m 80km/hr
R=170m L=60 m 65km/hr
R=170m L=60 m 65km/hr
R=90m L=55m 50km/hr
R=200m L=60 m 70km/hr
85
80
75
70
65
MATCH LINE
+3.5%
K35
-3.5%
K30
+0.35%
K46
-3.0%
K40
-0.35%
K45
-3.5%
BRONSON AVE
SLATER ST
ALBERT ST
BAY ST.
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST.
ELGIN ST
ORIGINAL GROUND
10+300
+400
10+500
+600
+700
+800
+900
11+000
+100
+200
+300
+400
11+500
+600
+700
+800
11+900
75
70
65
60
55
CHAMPAGNE AVE
K30
+3.5%
PRESTON ST.
K35
BOOTH ST. STATION
+0.35%
K30
+3.5%
WELLINGTON ST
BOOTH ST.
ORIGINAL GROUND
MATCH LINE
+300
+400
9+500
+600
+700
+800
+900
10+000
+100
+200
10+300
80
75
70
65
60
MACKENZIE KING BRIDGE
D.N.D.
K30
+0.35%
RIDEAU CANAL
COL. BY DRIVE
K20
+3.5%
NICHOLAS
WALLER ST.
K40
LAURIER AVE
-3.5%
K30
-0.35%
ORIGINAL GROUND
11+900
12+000
+100
+200
+300
+400
12+500
+600
+700
+800
+900

PLAN 1:6000
PROFILE 1:600

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN**

**PREFERRED ELEVATED OPTION**
**SLATER STREET**
**PLAN & PROFILE**

development of a station centered on Booth Street. However, this profile would necessitate a 6% gradient east of the above station. This gradient would jeopardize future conversion to a rail system and would introduce operational penalties for bus operations. By coincidence this profile would create an at-grade condition in the vicinity of existing Bronson Avenue.

In transitioning from the at-grade condition at Bronson Avenue to an elevated condition at Bay Street, the Transitway gradient adjacent to the existing homes on the north side of Slater Street would be up to 6% with obvious environmental impacts.

Depending on which alternative for the Bronson-Portage connection is to be pursued, the proposed elevated Transitway profile could require some relocation or deletion of major movements in both plan and profile. As an example, if Bronson-Portage alternative 11A[1] is considered, the Transitway would best be located between the eastbound Slater roadway and a remnant portion of existing Slater Street required to provide access to adjacent properties. This would, in turn, require a further encroachment of Slater Street on the Ottawa Board of Education property to the south.

Further consideration of this profile was rejected as it was not desirable to incorporate such a length of 6% grade which would negate opportunities to consider conversion to other vehicle technology in the future.

A further alternative utilizing a long 3.5% grade was introduced west of the Lyon Street station. This profile resulted in a Booth Street station approximately 4.5 to 5.0 m above the grade of Booth Street, and the Transitway reached the existing grade at Preston Street. More importantly, the structure would go through the middle of the proposed Bronson-Portage connection and could severely jeopardize the viability of the connection.

These attempts to avoid taking the Transitway over the Bronson-Portage connection, and still maintain 3.5% grades proved unsuccessful. Thus a final profile was developed to take the Transitway, after it left the Lyon Street station, over the Bronson-Portage connection and descend at a 3.5% grade. This resulted in a station at Booth Street 15 m above existing Booth Street. The Transitway profile continued to fall to the west and eventually grade was reached at approximately the Champagne Avenue connection.

Alternatively, if a 3.5% grade was maintained through the Booth Street area, thus precluding a station, the next feasible location for a station would be west of Preston Street.

All these major factors were recognized in the development of the profile, and the requirement to produce a technical option that at least responded to the same criteria as the other options, i.e.:

- maximum 3.5% grade,
- Station at Booth Street.

The Elevated Option profile that met these criteria required overpassing Bronson-Portage with a station at Booth Street considerably above the existing grade. This profile is also shown on **Exhibit 5.3.**

The existing overpass of Slater Street which allows student access between the two buildings of the Ottawa Technical High School would have to be removed for an elevated Transitway on Slater Street. The proposed Transitway profile would pass over Bay Street and allow development of a station between Bay and Lyon Streets.

Since the Bank Street station is expected to be the busiest of those in the downtown area, two station alternatives and resulting Transitway profiles were investigated. The first alternative would create a mezzanine level above the Bank Street/Slater Street intersection with the Transitway located above the mezzanine. The second alternative would locate the Transitway at minimum clearance over Slater Street, thereby requiring the mezzanine function to be incorporated into adjacent developments.

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[1] P-65-8-57-L1 RMOC drawing. Transportation Department.

The first alternative would require that the Transitway platforms be centered on Bank Street. The Transitway would be located approximately 10.5 m above Bank Street. This may be of concern since the visual intrusion of the Transitway would extend to the fifth floor of the adjacent buildings. However, the mezzanine level of such a station could be accessed directly from all four corners of the Bank Street/Slater Street intersection.

The second alternative would locate the Transitway 6.5 m above Bank Street with a lower visual impact than the first alternative. However, this alternative would require that passenger access be integrated with adjacent development to provide a means of reaching either transit platform from the opposite side of Slater Street. If the necessary cross-over structure was located above the Transitway it would be approximately 13 m above street level with resulting vertical travel concerns. If the cross-over structure was located below street level, the vertical travel would require approximately 10.5 m of rise as in the first alternative. A third option for handling passenger access would be the creation of two smaller mezzanines, one for each direction. This is operationally undesirable.

The higher Transitway profile was selected in order to facilitate transit passenger access, and this station concept was utilized at Lyon, Bank and Metcalfe. This would avoid an undulating Transitway profile which would compound its negative visual impact.

The proposed profile could continue to fall easterly at a minimal gradient to create a station east of the Rideau Canal at approximately the same elevation as the MacKenzie King Bridge. This station would occupy portions of three floors of the two most northerly bays of the National Defence Headquarters. The technical feasibility of these major renovations to this building is reported on later. The policy issue of whether or not such an encroachment is acceptable is not answered in this report.

The above configuration for a station would minimize the additional visual intrusion of a Transitway and, at the same time, obviate the reconstruction of the MacKenzie King Bridge because of transit. However, it should be noted that there is a current suggestion that for other reasons the MacKenzie King Bridge should be completely reconstructed.

If the above encroachment on the National Defence Headquarters were to be technically or politically unacceptable, a Transitway profile above that of the MacKenzie King Bridge could be developed. This transitway profile would be located about 6.5 m above the deck of the MacKenzie King Bridge. Any required mezzanine area would most easily be located below the bridge deck. This option was an unacceptable alternative as defined in Phase I work because of the very significant impacts on the views along the Canal.

The location of the transit station immediately above the MacKenzie King Bridge would preclude a lowering of the profile west of the Rideau Canal to match that of the MacKenzie King Bridge. While the Transitway alignment could be diverted southerly starting west of Colonel By Drive to eventually parallel the MacKenzie King Bridge, the profile could not start dropping relative to the bridge until the edges of the two structures were completely separated in plan. This, together with the requirement to overpass Elgin Street, would severely limit any lowering of the Transitway profile.

The elevated Transitway profile would join the existing Transitway approximately 300 m south of Laurier Avenue.

### 5.5 Structural Considerations of the Elevated Option

This section summarizes the structural investigation of the elevated option for the Central Area Transitway. Various issues, which were identified during Phase I of the study, were given more detailed analysis during the refinement of the option. These include:

(a) alignment of the Transitway east of Elgin Street including the feasibility of going over the NAC parking garage and through the D.N.D. building,

(b) superstructure/pier configuration with consideration of clearances, utility conflicts, constructability and basis for costing,

(c) construction techniques, staging, timing,

(d) structural considerations with respect to station alternatives.

### 5.5.1 Alignment and Profile - Structural Implications

The basic alignment of the elevated option is along Slater Street from Bronson Avenue to Elgin Street, across the Rideau Canal at the MacKenzie King Bridge, and then south along Waller and Nicholas Streets to Campus Station.

East of Elgin Street, the preferred alignment passes over the NAC parking garage, across the Canal just south of the MacKenzie King Bridge (at existing deck level), and through the north end of the D.N.D. building to Waller Street. Major conflicts exist at the NAC parking garage and at the D.N.D. building.

At the NAC parking garage support columns for the Transitway structure would have to be constructed through three levels of parking and through the roof of the garage. These support columns would fall within and interfere with traffic circulation aisles in the garage. At the east side of Elgin Street, a support column would conflict with the Elgin Street entrance ramp to the garage. In addition, conflicts exist between the Transitway structure and stairwell exits and ventilation outlets in the garage roof.

There is no opportunity to maintain the alignment over the NAC parking garage and avoid or reduce the above conflicts to an acceptable degree without a major reconstruction of that facility. Consequently, an alternative alignment, which routes the Transitway south of the NAC garage (into the park) has been adopted for this study. This eliminates all the above conflicts with the exception of the support column at the Elgin Street entrance ramp. Here the entrance ramp has to be realigned. This would cut off the present access to the garage from Slater Street.

At the D.N.D. building the Transitway would pass through the north end of the building between column lines 85 and 91. Four main building columns at the NW tower on column line 87 conflict with the proposed right-of-way and would have to be removed between the second and fifth floors. This is structurally feasible, but involves very difficult and complex engineering design and construction. Removal and replacement of the four columns would require the construction of four large transfer girders between the fourth and fifth floors to pick-up these columns from above and the construction of eight new columns to carry the transfer girders.

In order to provide the required vertical clearance through the D.N.D. building, both the third and fourth floors would have to be removed between column lines 85 and 91.

The impact of these changes on the D.N.D. building is considerable. The third floor (foyer level), which is the main access to the building from MacKenzie King Bridge and the north side would be cut off by the Transitway. The main access could be moved to the second floor level. The fourth floor is a mechanical floor and removal of a part of that floor will require relocation of some mechanical equipment including fresh air intakes, plenums, and air filters. The impact on the ventilation system and the feasibility of equipment relocation is not known. A single large support column for the Transitway structure and four of the eight new building columns would have to be located within the existing building and would be constructed through the second, first, and basement floor levels below, thus impacting on the use and occupancy of these floor areas as well.

West of Elgin Street along Slater Street, the Transitway would be centered on the right-of-way over the full length of the street. This is required at the stations because of the limited clearance available.

For the purposes of this study, the so-called "high profile" has been adopted along Slater Street. This permits the station mezzanine to be below the Transitway, which would be desirable from a user perspective. The Transitway deck would be approximately 10 m above street level. The higher profile results in a more costly substructure as larger pier columns and foundations are required to resist lateral loads.

The alternative "low profile" places the station mezzanine and Transitway at the same level, approximately 8 m above street level. With the lower profile, the user would have to cross over the top of the Transitway to get to the opposite platform. This was judged to be an undesirable condition.

East of Elgin Street, the profile is dictated by vertical clearance requirements at the D.N.D. building, Nicholas and Waller Streets, as well as the desire to cross the Rideau Canal at or close to the same elevation as the existing MacKenzie King Bridge. The resulting profile is a compromise. At the Canal, the Transitway profile is about 0.5 m higher than the existing bridge. East of the D.N.D. building, it is approximately 1.0 m higher and Waller Street would have to be lowered about 0.5 m to provide the necessary vertical clearance.

### 5.5.2 Structure/Pier Configurations

The cross-section shapes which are shown in **Exhibit 5.4** are illustrative only and are representative sections for assessing clearance requirements, urban impact, costs, etc.

A 4.2 m platform width, 2.75 m lane width, and 1.25 m median width have been adopted at the stations. This is less than the desired width, but the reduction is necessary in order to fit the structure within the right-of-way on Slater Street and still provide some clearance between the Transitway structure and buildings for maintenance and clearance. The lane widths are minimal due to the use of the guided busway concept for steering. This is described later. However, no provision for passing lanes at stations was possible.

Between stations, the cross-section is an extension of that at the station with the curb to curb dimension of 6.75 m. At the D.N.D. building the overall width of the structure is 8.48 m to clear the building columns.

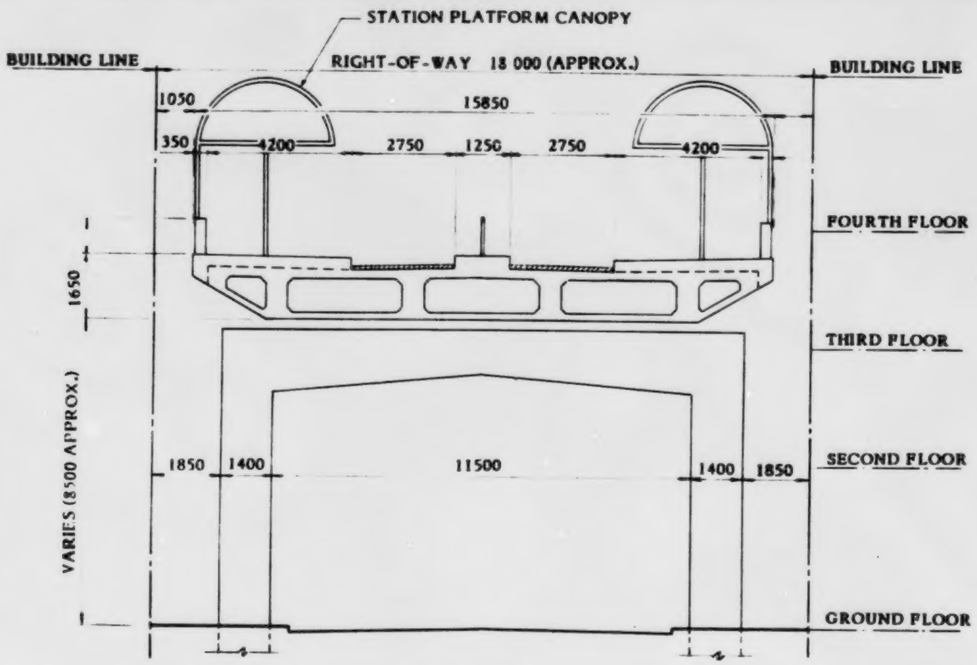
Along Slater Street a two column pier bent configuration has been used. This configuration is necessary at the stations due to the width of the cross-section. Between stations a similar configuration has been used, rather than a single centre column. This avoids conflict with large sewers and Bell Telephone duct installations along the centre of the street. The section illustrated leaves approximately 1.8 m clear between the pier column and building line. An 11.5 m clearance between columns leaves room for three lanes of traffic. This option reduces the traffic lanes from four to three lanes on Slater Street. The pier supports also introduce a pedestrian conflict along the sidewalks.

Along Slater Street, the foundations would be constructed to minimum dimensions to reduce conflict with utilities as much as possible. It is likely that large diameter drilled piles socketed into bedrock would be used. East of Elgin Street, steel H-piles driven to bedrock could be used.

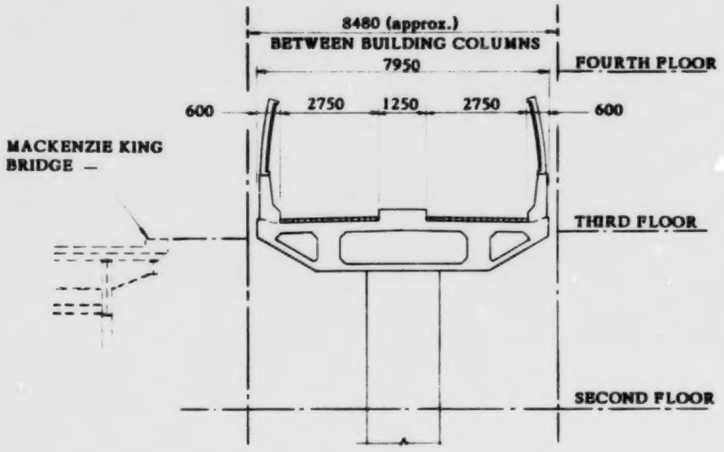
### 5.5.3 Construction

Construction of the elevated transitway would involve several major and distinct activities including utility relocation, foundation construction, pier construction, and superstructure construction. This work would be carried out on a progressive basis with each activity following the preceeding work block by block.

**EXHIBIT 5.4**


STATION PLATFORM CANOPY
BUILDING LINE
RIGHT-OF-WAY 18 000 (APPROX.)
BUILDING LINE
1050
15850
350
4200
2750
1250
2750
4200
FOURTH FLOOR
1650
THIRD FLOOR
VARIES (8500 APPROX.)
1850
1400
11500
1400
1850
SECOND FLOOR
GROUND FLOOR

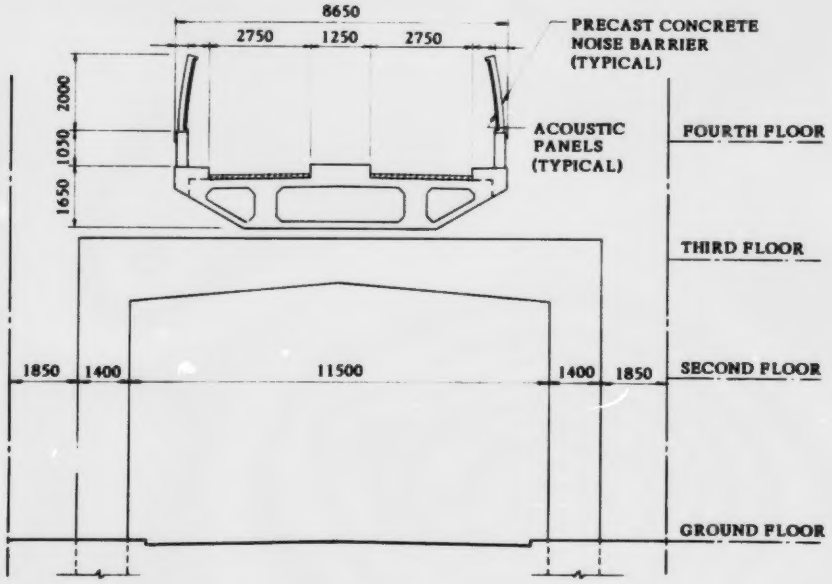
TYPICAL SECTION AT STATION


8480 (approx.)
BETWEEN BUILDING COLUMNS
7950
FOURTH FLOOR
600
2750
1250
2750
600
MACKENZIE KING BRIDGE
THIRD FLOOR
SECOND FLOOR

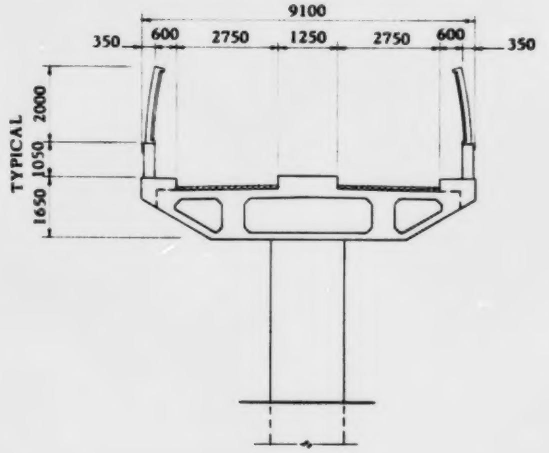
TYPICAL SECTION AT DND BUILDING

NOTE:

GUIDED BUS TECHNOLOGY, USING LOW HORIZONTAL GUIDE WHEELS OPERATING AGAINST THE CURB, WILL PERMIT NARROW RUNNING LANES.


8650
2750
1250
2750
PRECAST CONCRETE NOISE BARRIER (TYPICAL)
2000
1050
1650
ACOUSTIC PANELS (TYPICAL)
FOURTH FLOOR
THIRD FLOOR
1850
1400
11500
1400
1850
SECOND FLOOR
GROUND FLOOR

TYPICAL SECTION BETWEEN STATIONS (SLATER STREET)


9100
350
600
2750
1250
2750
600
350
TYPICAL
2000
1050
1650

TYPICAL SECTION (CENTER SUPPORT COLUMN)

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / GRIFFITHS, RANKIN & COOK

## STRUCTURAL CROSS-SECTIONS OF ELEVATED OPTION

### Utility Relocation

This activity involves the relocation of all utilities, both overhead and underground, which interfere with pier columns and foundations. Relocation of underground utilities would generally involve abandonment of the facility between manholes over the length that conflict occurs and construction of a new facility between those manholes. Local deflection or relocation of hydro duct banks, watermains, etc., at individual piers is generally not practical. Consequently, utility relocation will involve opening up trenches and constructing new facilities along the entire length of Slater Street. This work would be carried out on a progressive basis, generally one block at a time, although only short lengths of trench would actually be open at any one time.

Utility relocation work could be confined to one side of Slater Street at a time. This would allow two lanes of traffic to remain on the street during this activity.

In one instance a 24 inch watermain has to be relocated the full length of Slater Street. This main would likely be relocated to another street and would require several months lead time. The work would likely be done under a separate contract well in advance of Transitway construction. Other relocation work would follow a similar pattern, i.e., be carried out under a separate contract in advance of Transitway construction.

### Foundation, Pier, Superstructure Construction

Structural work can generally not begin until utility relocation is complete within a given block, as the new utilities have to be installed and commissioned prior to abandoning the existing facilities.

Excavation and construction of the foundations and pier bents would proceed progressively along the street with individual operations following closely one behind the other. Construction of the superstructure would follow once sufficient piers were completed.

As with the utility relocation work, pier foundation and column construction could be confined to one side of Slater Street at a time permitting two lanes of traffic to remain on the street. The pier bent girders would be cast-in-place on scaffolding. Again, two lanes of traffic could be maintained by bridging the girder formwork across the street. Operations which require closing of the street to all traffic, such as erection of scaffold beams and formwork over the traffic lanes could be performed at night.

Construction of the superstructure, whether cast-in-place on scaffolding or precast and erected, would result in complete closure of the street to all traffic except construction and emergency vehicles. Pedestrian access to all building entrances on the street would be maintained throughout the course of construction.

### Station Construction

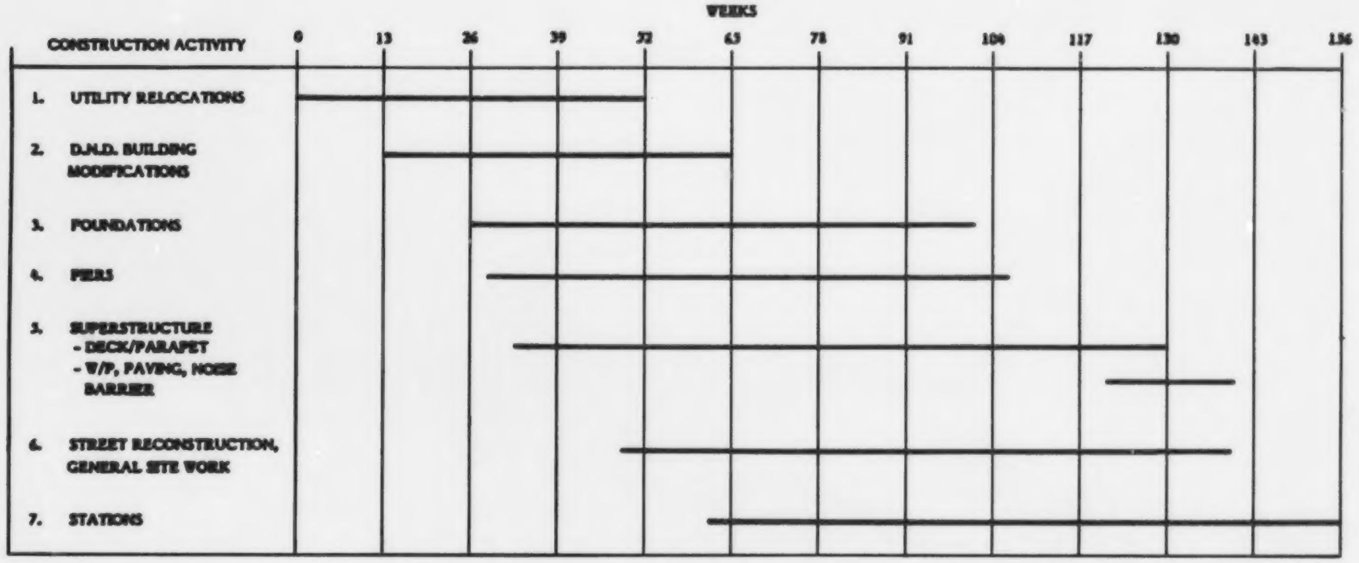
Station concepts would require some utility relocation and construction in and over the cross streets, which would cause considerable disruption to traffic with some lane closures and entire street closures during erection over the street.

### Work Schedule

The duration of construction **(Exhibit 5.5)** of the Transitway structure within any single block on Slater Street would be approximately 4 to 5 months (not including utility relocation). The street would be completely closed to traffic for approximately 1½ to 2½ months depending on whether the structure is precast or cast-in-place. It would be restricted to two lanes for the remaining 2½ months. No more than two adjacent blocks would be completely closed to traffic at any one time. Construction activity would span over a three block stretch of Slater Street at one time. The total

**EXHIBIT 5.5**

RMOC CENTRAL AREA TRANSITWAY
ELEVATED OPTION



CONSTRUCTION SCHEDULE

duration of construction on the seven block Bronson to Elgin Street section would be approximately three years. This could be shortened to two years if two concurrent contracts were let for this section. However, virtually the entire length of Slater Street would then be under construction during that two year period.

Construction of the section east of Elgin Street would take a similar period of time and could be undertaken concurrently with the construction on Slater Street. Disruption to traffic would be far less severe and generally it could be routed around construction areas without too much difficulty. Across Elgin Street there would be some temporary lane closures and turning movement restrictions.

### 5.5.4 Station Location and Form

For the elevated option, four station locations were investigated:

1. Between Bay Street and Lyon Street.
2. Centred on Bank Street.
3. Between Metcalfe Street and Elgin Street.
4. MacKenzie King/D.N.D.

During the assessment of the station, two concepts were developed. In the first concept, the transitway was kept at the +6 m level and the station developed at the same elevation; however, the eastbound transit patrons would have had to go up one level higher, cross over and descend again to the other platform. Also, it appeared that the view under the Transitway for anyone on Slater Street would have been more restricted and the environment under the Transitway would have been closed in, restricted and dark. Accordingly, the Transitway was elevated to a higher level and this allowed sufficient head room for pedestrians to cross to the eastbound platform under the Transitway.

The following exhibits illustrate the station concepts for the elevated alternative at selected central area locations.

### Lyon Street Station

This station concept is shown for illustrative purposes on **Exhibit 5.6.** It would require property acquisition on the north and south sides of Slater Street, immediately west of Lyon Street. Transit users would access the station through the entry on the north side of Slater Street, pass through fare control and up one level to the pedestrian cross-over level. The westbound passengers would then go up directly to the westbound platform. The eastbound passengers would cross the street and go up to the eastbound platform from the south side of Slater Street.

### Bank Street Station

As discussed earlier, there were two station concepts for Bank Street. The first concept developed a deck over the intersection and provided access to this mezzanine level from all four corners. This concept is illustrated in **Exhibit 5.7.** From the mezzanine level, the passengers ascend to the Transitway platforms one level above the mezzanine.

The second concept developed the station over Bank Street, but north of Slater Street. In this case, the intersection area is not completely decked, at the mezzanine level. Access is from both sides of Bank Street, north of Slater Street. This concept is presented in **Exhibit 5.8.**

Alternative concepts were examined that integrated the station into adjacent development on private property.

### Metcalfe Street Station

This concept is essentially the same as the one proposed at Lyon Street and involves the development of the station using the piece of land on the north side of Slater Street behind the National Gallery. A small piece of property is required on the south side of Slater Street. It would function in the same manner as the station concept proposed at Lyon Street.

### Rideau Centre Station

This is a particularly difficult station to develop due to the Transitway alignment south of and parallel to the MacKenzie King Bridge, and the resulting impact on the D.N.D building. The proposal is to develop the station at the east end of the D.N.D. building, with access provided from the Rideau Centre under the bridge. The platforms extend out to the east over Nicholas St. This concept is illustrated on **Exhibit 5.9.**

An access can be developed at the east end of the platform to accommodate a link to the northern part of the University of Otttawa campus. This would likely be an automatic, non-manned, station entrance/exit.

### View Under the Transitway

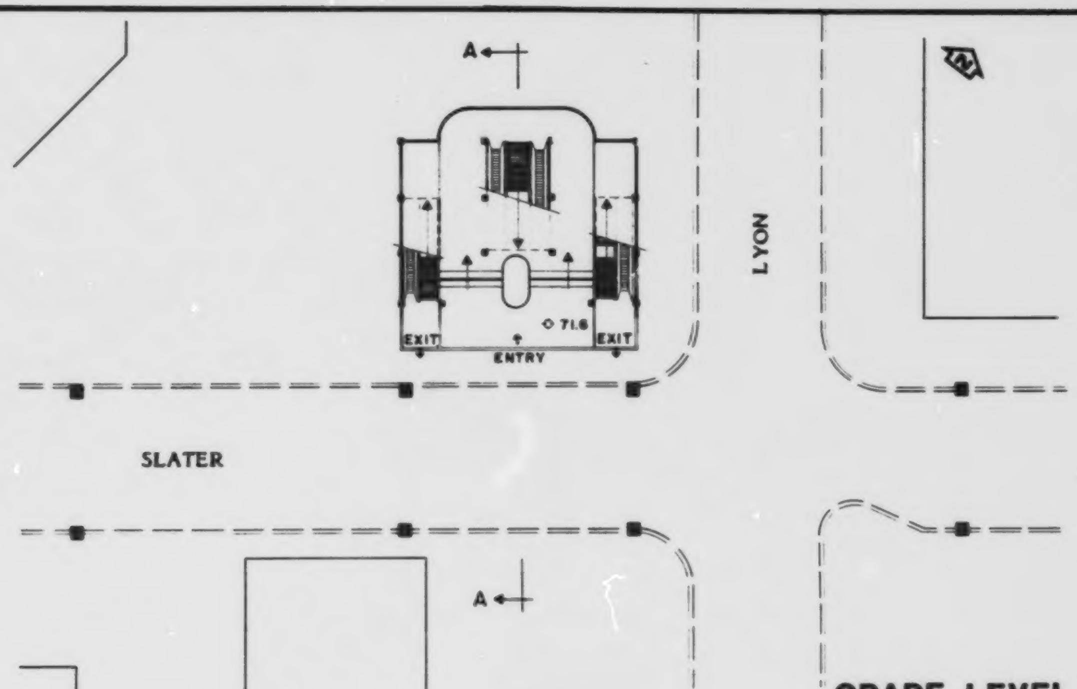
**Exhibit 5.10** provides a perspective of a view under the two-level high structure at a station area. The adjacent buildings at the first three or four levels will be impacted quite substantially. High quality lighting and urban design elements would have to be incorporated into this concept to create an attractive area under the structure. The primary disadvantage would be the lack of direct sunlight.

## 5.6 Operations

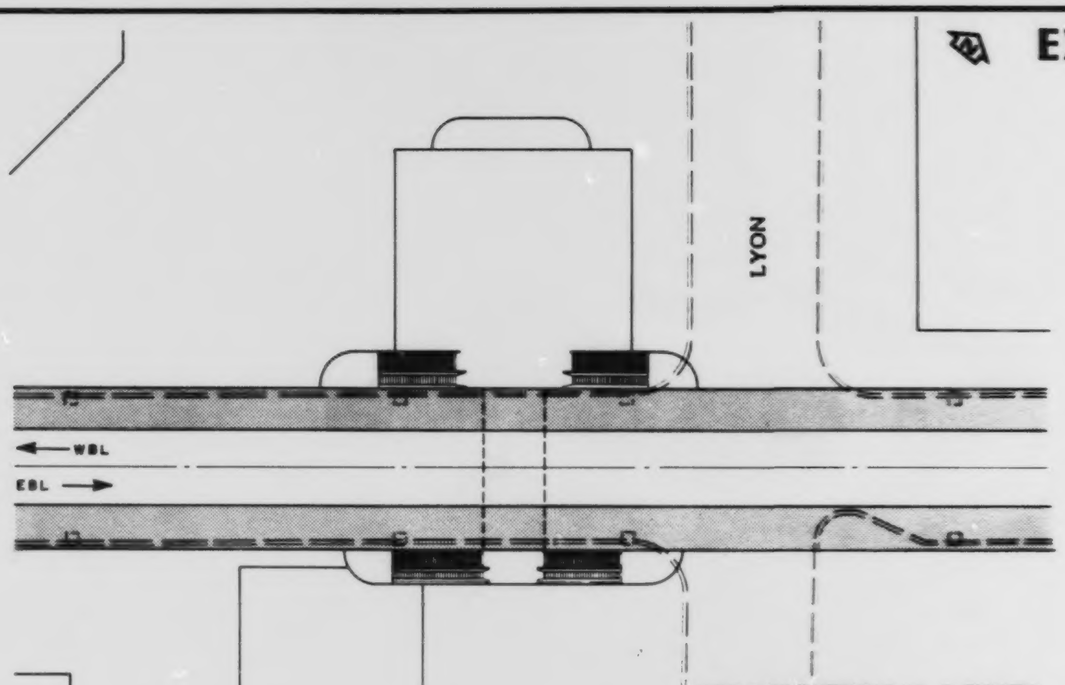
### 5.6.1 Vehicle Characteristics

The elevated option would present a number of operational constraints. To overcome some of the concerns with respect to operating a bus on an elevated structure, use of "guided" bus technology can be considered. This is a German development that has been successfully implemented in several cities in Germany and recently has been introduced to Adelaide, Australia (see **Exhibit 5.11**). Essentially the technique calls for small horizontally mounted wheels on the front axle of the bus. These wheels extend 50 mm

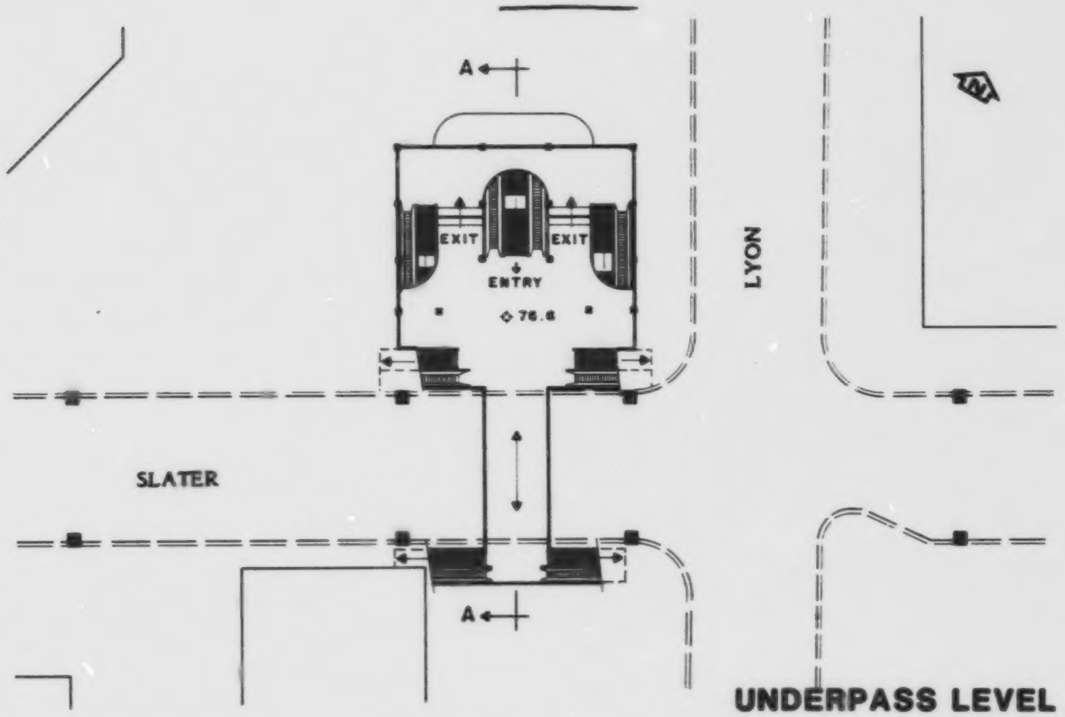
**EXHIBIT 5.6**


A
EXIT
ENTRY
EXIT
◇ 71.6
LYON
SLATER
A

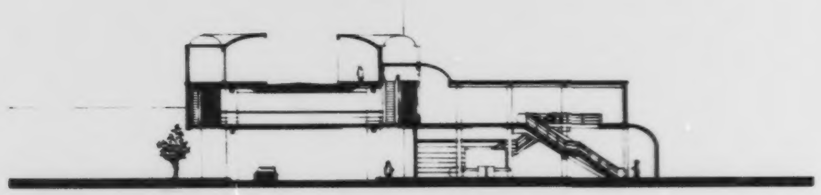
**GRADE LEVEL**


LYON
WBL
EBL

**TRANSITWAY LEVEL**


A
EXIT
EXIT
ENTRY
◇ 76.6
LYON
SLATER
A

**UNDERPASS LEVEL**

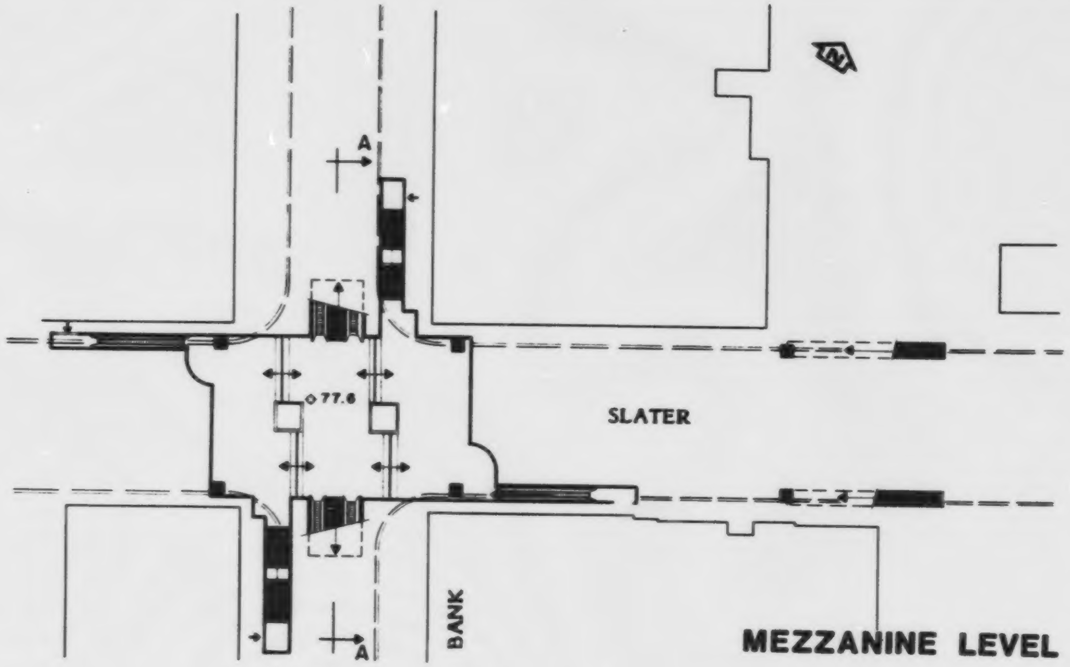


**SECTION A-A**

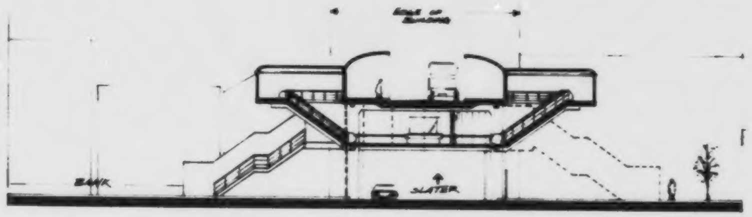
REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / GRIFFITHS, RANKIN & COOK

## ELEVATED OPTION
## LYON STREET
## STATION CONCEPT

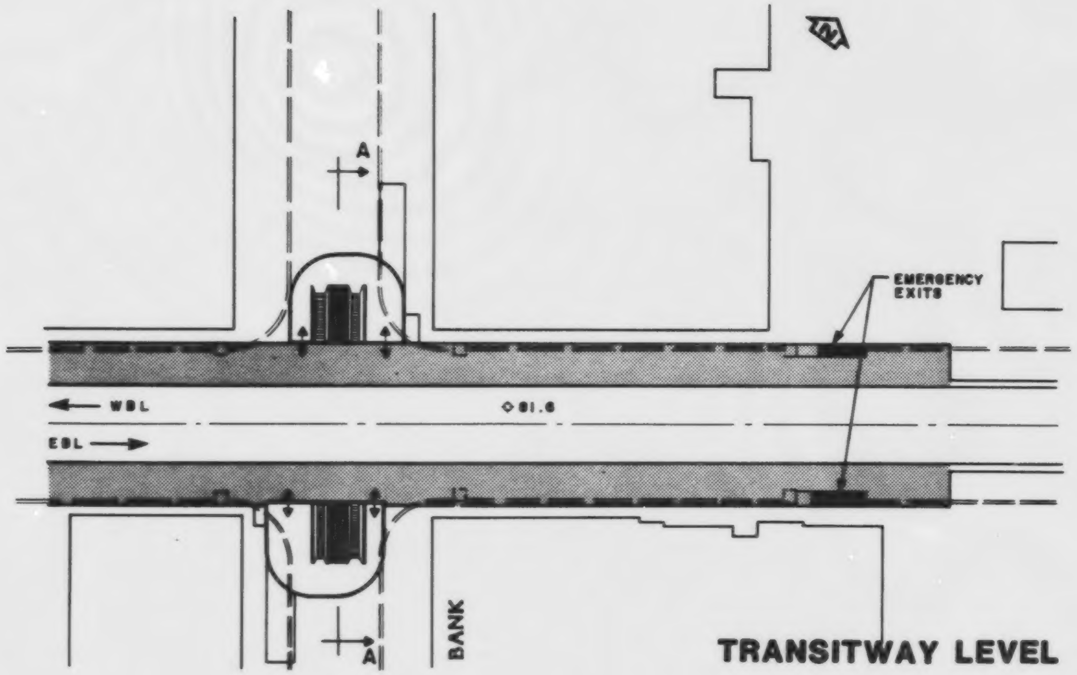
**EXHIBIT 5.7**


N
A
A
◇77.6
SLATER
BANK

**MEZZANINE LEVEL**


BANK
SLATER

**SECTION A-A**

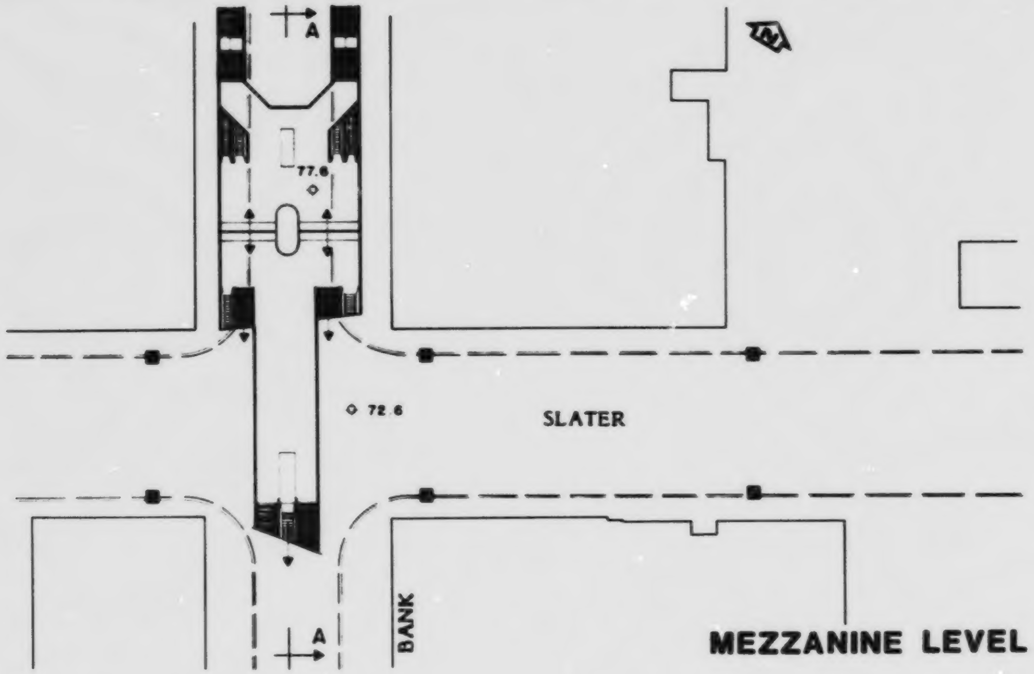

N
A
A
EMERGENCY EXITS
WBL
EBL
◇81.6
BANK

**TRANSITWAY LEVEL**

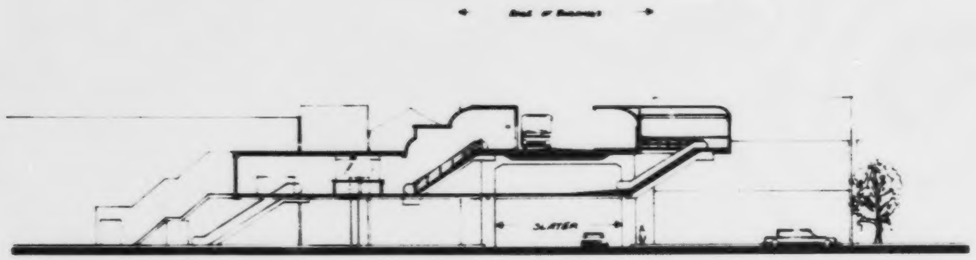
REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / GRIFFITHS, RANKIN & COOK

## ELEVATED OPTION
## BANK STREET
## STATION CONCEPT #1

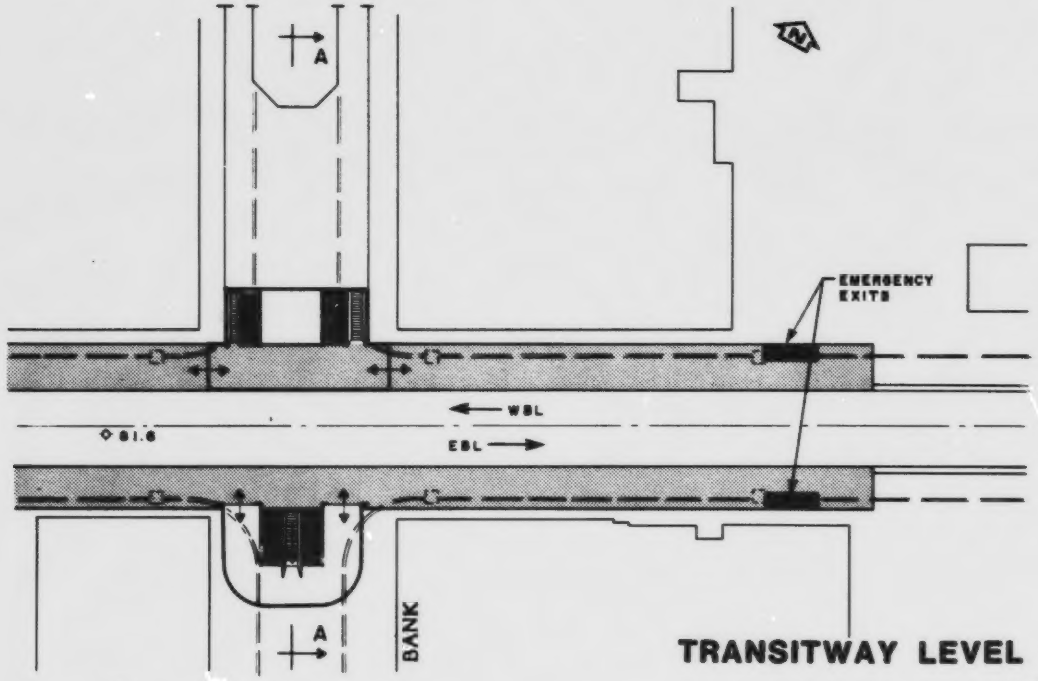
**EXHIBIT 5.8**


A
77.6
72.6
SLATER
BANK
A

**MEZZANINE LEVEL**



**SECTION A-A**


A
EMERGENCY EXITS
WBL
81.6
EBL
BANK
A

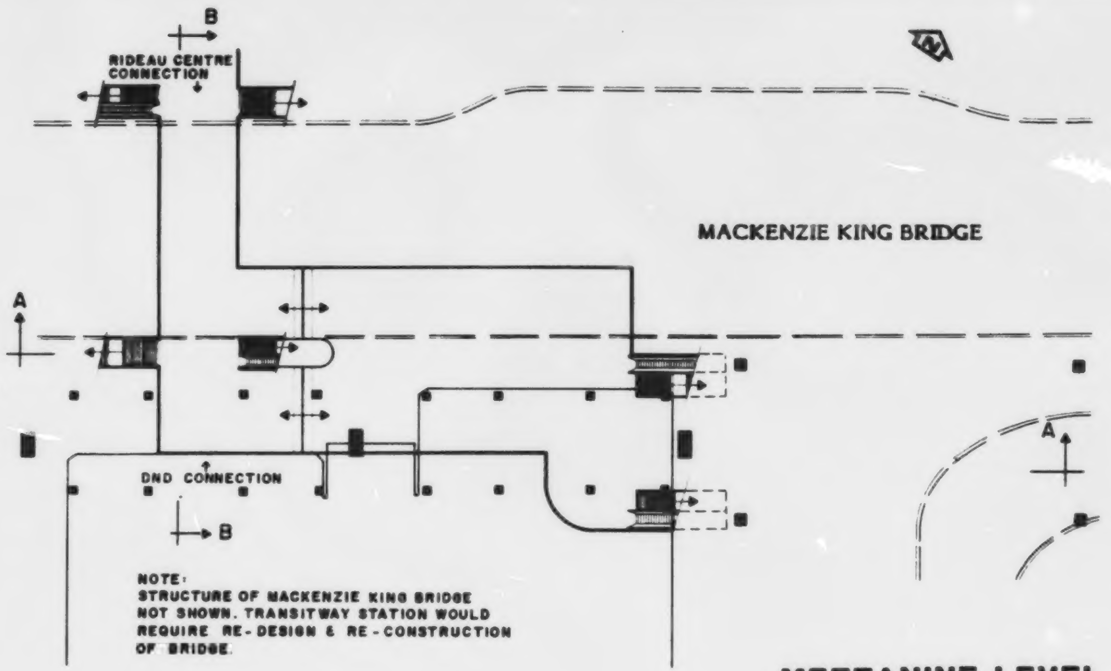
**TRANSITWAY LEVEL**

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

DELCAN / GRIFFITHS, RANKIN & COOK

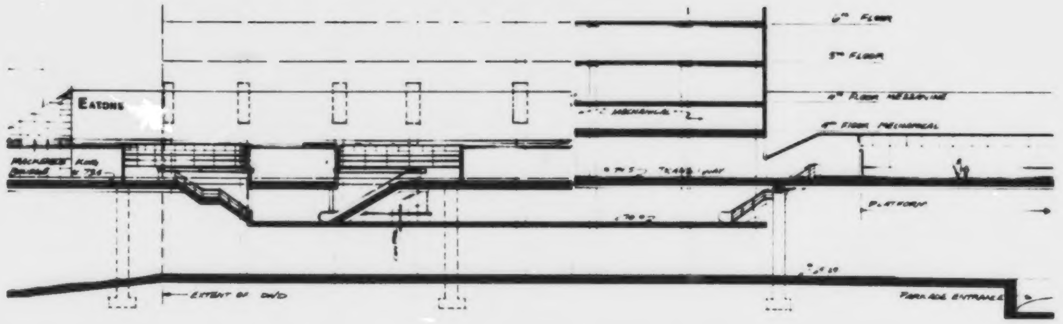
**ELEVATED OPTION**
**BANK STREET**
**STATION CONCEPT #2**

## EXHIBIT 5.9

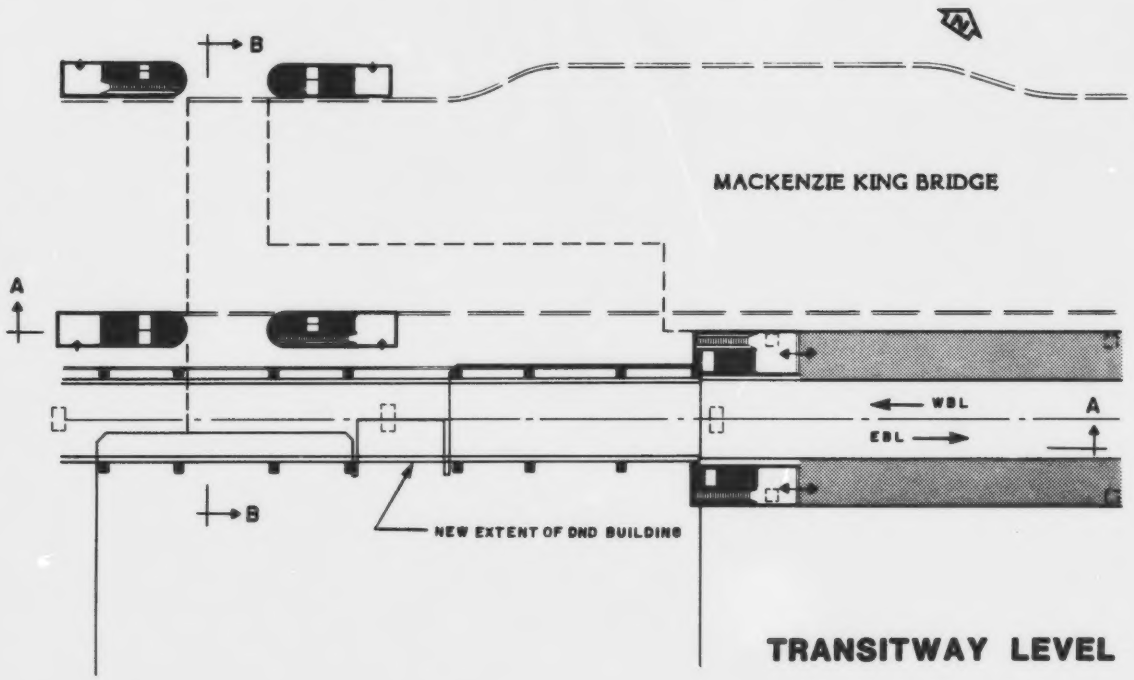

B
RIDEAU CENTRE CONNECTION
N
MACKENZIE KING BRIDGE
A
DND CONNECTION
B
A

NOTE:
STRUCTURE OF MACKENZIE KING BRIDGE NOT SHOWN. TRANSITWAY STATION WOULD REQUIRE RE-DESIGN & RE-CONSTRUCTION OF BRIDGE.

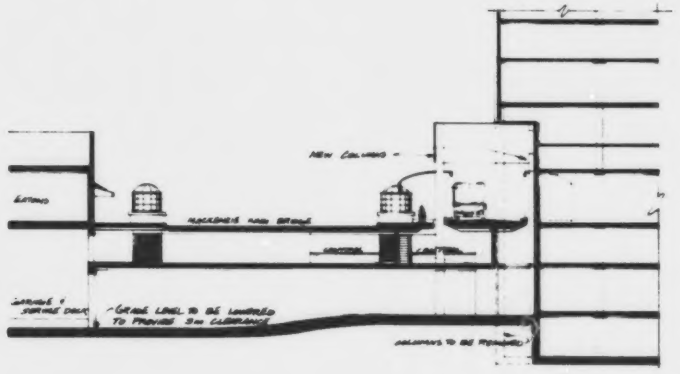
**MEZZANINE LEVEL**


EATONS
6th FLOOR
5th FLOOR
4th FLOOR MEZZANINE
4th FLOOR MECHANICAL
MECHANICAL
MACKENZIE KING BRIDGE
TRANSITWAY
PLATFORM
EXTENT OF DND
PARKADE ENTRANCE

**SECTION A-A**


N
B
MACKENZIE KING BRIDGE
A
WBL
EBL
A
B
NEW EXTENT OF DND BUILDING

**TRANSITWAY LEVEL**


NEW COLUMNS
EATONS
MACKENZIE KING BRIDGE

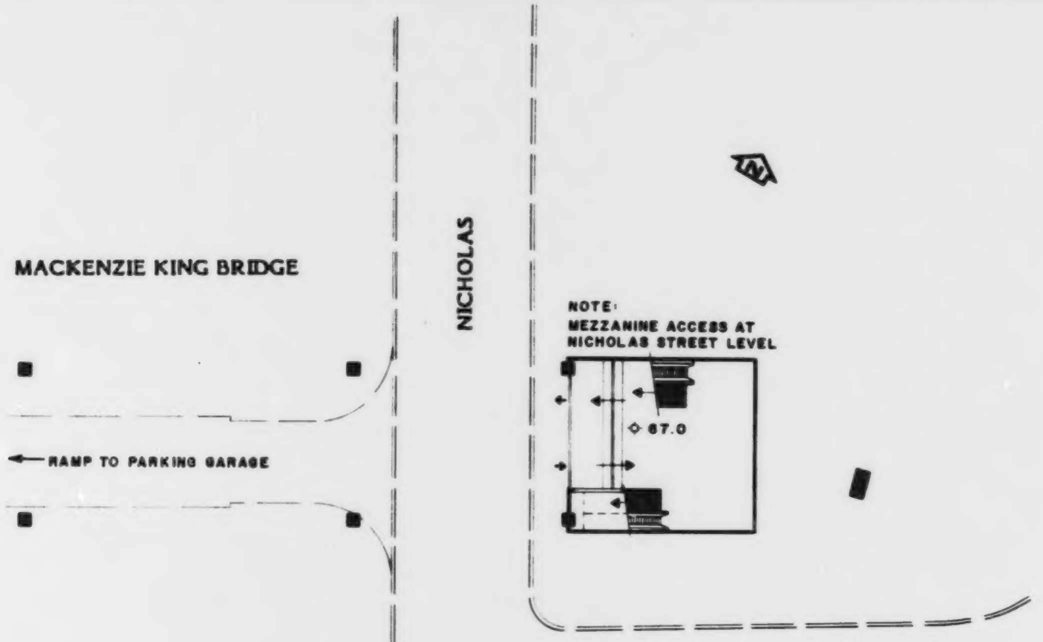
**SECTION B-B**

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

DELCAN / GRIFFITHS, RANKIN & COOK

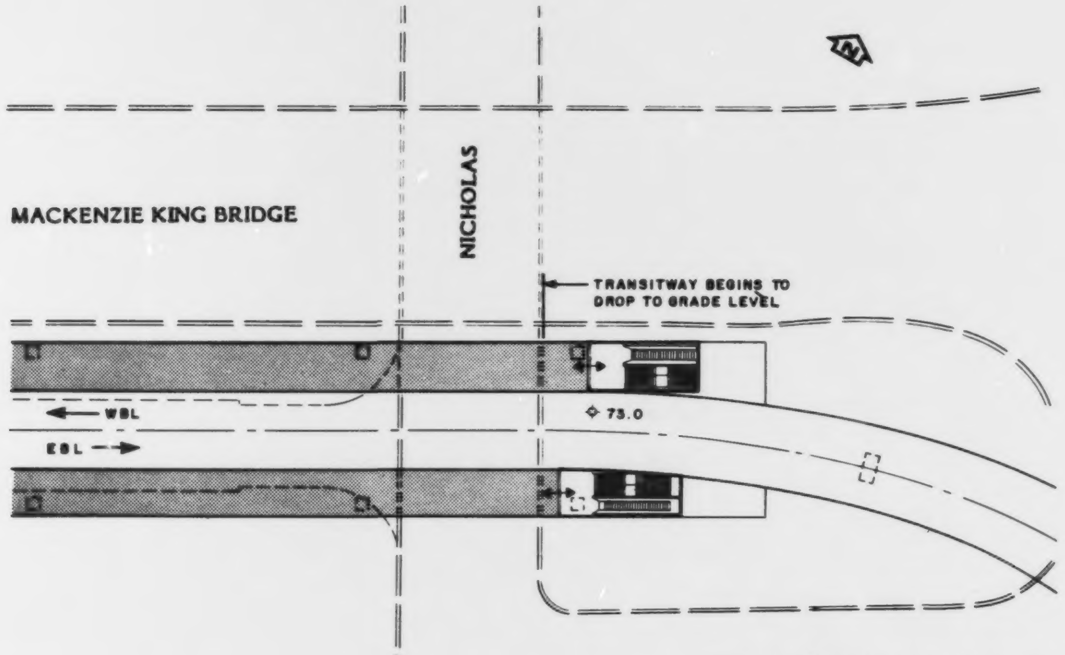
## ELEVATED OPTION
## MacKENZIE KING
## STATION CONCEPT

**EXHIBIT 5.10**



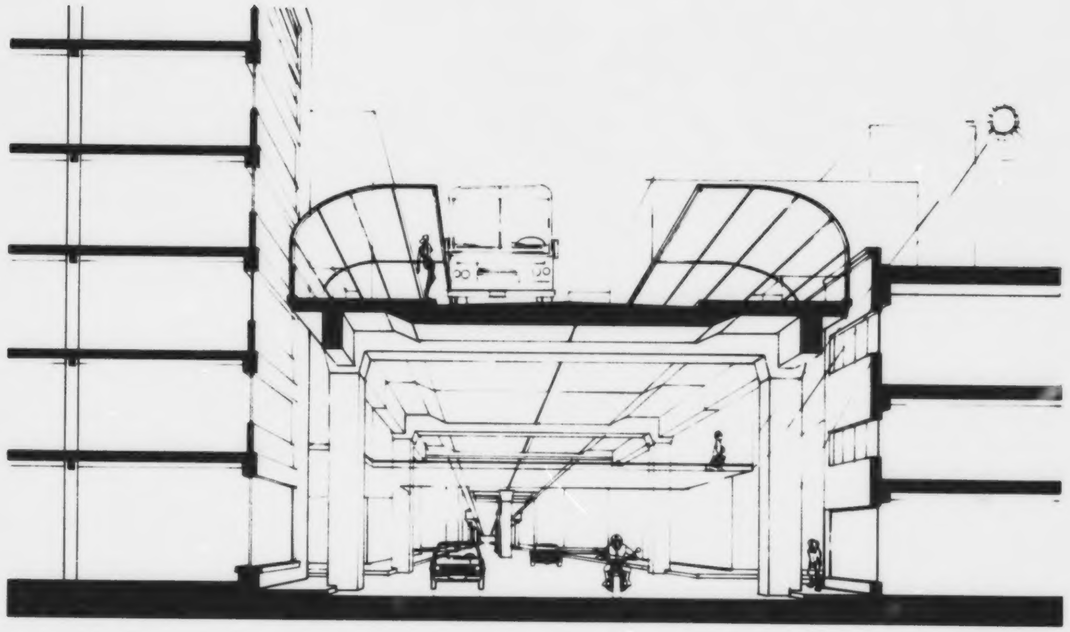
MACKENZIE KING BRIDGE
NICHOLAS
NOTE:
MEZZANINE ACCESS AT
NICHOLAS STREET LEVEL
◇ 67.0
RAMP TO PARKING GARAGE
N

GRADE LEVEL



N
MACKENZIE KING BRIDGE
NICHOLAS
TRANSITWAY BEGINS TO
DROP TO GRADE LEVEL
◇ 73.0
WBL
EBL

TRANSITWAY LEVEL



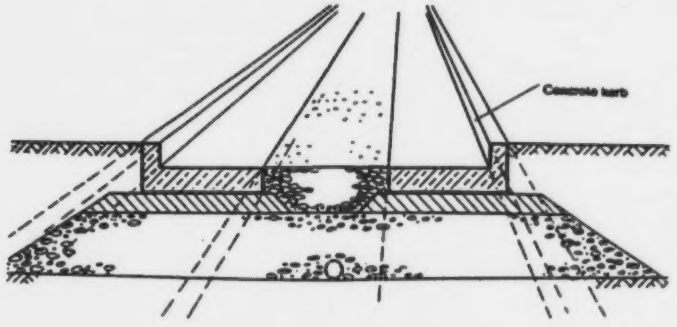
VIEW ALONG SLATER
UNDER STATION AREA

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

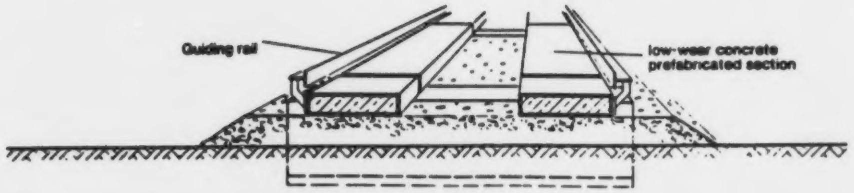
**DELCAN** / GRIFFITHS, RANKIN & COOK

**ELEVATED OPTION**
**VIEW UNDER TRANSITWAY**
**IN CENTRAL AREA**

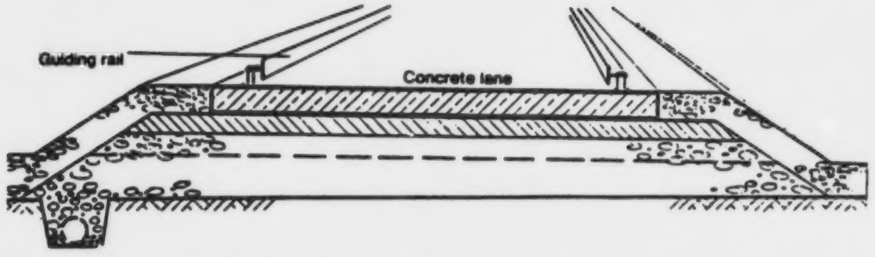
**EXHIBIT 5.11**


Concrete kerb

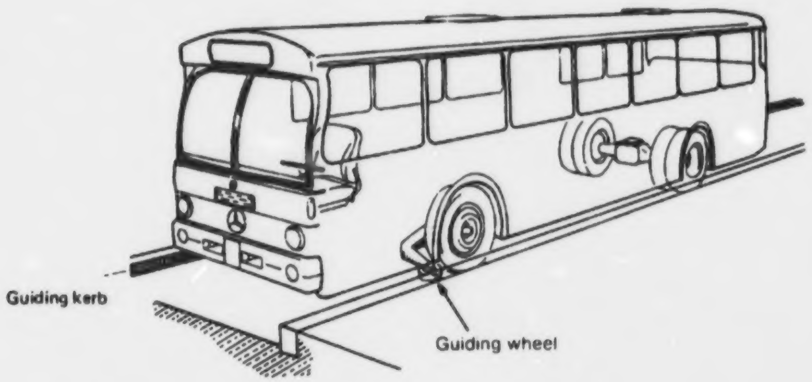
Guideway of road-strip sections at grade with concrete guiding kerbs


Guiding rail
low-wear concrete prefabricated section

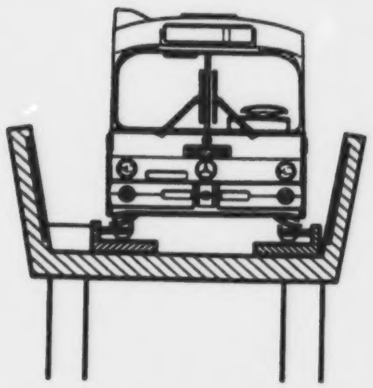
Steel side rail and concrete kerb are both recommended.


Guiding rail
Concrete lane

Ground conditions and costs may favor full-width concrete slabs, cast in place.

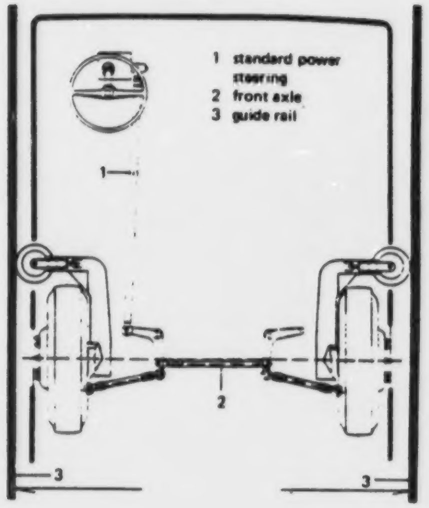

Guiding kerb
Guiding wheel

Arms position guided bus within curbed way.



Noise barrier walls and walkways can be added to guide rail and road strip.

Safe positive connections link wheels with rollers and driver steering wheel.


1 standard power steering
2 front axle
3 guide rail
1
2
3
3

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN**

## ELEVATED OPTION
## GUIDED BUSWAY CONCEPT

beyond the side of the bus and run against a small vertical reaction rail or curb. The small wheels take over the steering of the bus, leaving the driver to concentrate on smooth accelleration and stopping at precise platform locations. The net result is a slightly narrower roadway, and because the bus always runs along the same path, a very smooth running surface can be provided. Of equal importance will be the additional safety feature associated with driving the bus on an elevated facility. In addition, the bus running paths can be kept ice free through a heating system, although these systems have not had good maintenance records. A double system would have to be installed with provision for replacement at more frequent intervals, and possibly the entire deck would have to be heated to prevent snow build up.

The components of the guided bus system have been tested thoroughly but have not received widespread application due to the fact that the special operating conditions for applicability of the technology are not common.

Other benefits can accrue from the use of this technology, one in particular is of interest. This relates to the potential to use a slightly raised platform which would almost eliminate the first step to board the bus and could contribute to faster boarding.

There are special procedures that would have to be employed to handle bus breakdowns. The buses have a special inner wheel in the tires to allow the bus to clear the system in the event of a flat tire, The designers of the system advocate a bus push or tow bar to enable a following bus to push the leading bus at a reduced speed. Tow vehicles would also be required.

The added cost for fitting a vehicle with this steering equipment is estimated to be $13,000 to $15,000 per bus.

This method of operations will require that "no passing" occur. The operations analysis conducted as part of this project indicate that although it is possible to achieve the required throughput without passing, it is an advantage from the operational flexibility viewpoint to have the ability to pass at stations, as it is expected that any bus breakdown would likely occur in a station. The flexibility of passing a disabled bus would be lost.

The regular diesel buses, refitted as explained above, would be able to operate on the elevated Transitway. There would be no enclosed sections and consequently ventilation would not be a factor. At the stations, the passenger areas would be covered using canopies as illustrated in the station concepts. The cost of heating the deck could be eliminated at the cost of ventilation and additional visual impact if the entire transitway were covered; however, fire fighting needs would preclude this.

Operations on the Transitway would be halted during times when the fire department would require access to respond to emergencies along the length of Slater Street. During such emergencies, transit operation would have to revert to surface routes. This is an major operational constraint that would pose significant difficulties to OC Transpo. From February 1986 to November 1988, over 200 fire department responses to Slater Street were recorded and this does not include pass-throughs in response to other locations. In addition, there have been approximately 2 occasions per year when heavy cranes needed access to Slater Street. These vehicles could not be accommodated on an Elevated Transitway. Accordingly, an elevated transitway through the central area that covers the street to the extent indicated in this concept does not appear to be acceptable.

### 5.6.2 Passenger Control

In the elevated Transitway option, the passengers gain access from the street either through a joint use development or into the station directly. They would travel up to the first level and go through the fare control area. The westbound passengers would then go up one more level to gain access to the westbound platforms. Eastbound passengers would have to pass from the fare payment area, across the street on the pedestrian crossing, and then go up one level to the eastbound platforms. This concept would rely on the ability to integrate the station areas into adjacent development in order to develop elevator access to the platform level on the east side.

### 5.6.3 Snow Removal

Since the elevated option is a relatively narrow structure there is no room for storage of snow removed from the bus lanes. It would also be impractical to blow snow off the structure onto streets below. The only solution is a snow melting system using embedded electrical cables in the roadway to melt and largely evaporate the snow as it falls. Drains would have to be equipped with heat-tracing cables to prevent melted snow from freezing in them. As stated earlier, these heating systems are not reliable and require significant maintenance.

## 5.7 Central Area Integration Impacts

The most difficult and challenging aspect of an elevated concept is the integration of the facility into the fabric of the Central Area. Any major transportation facility through the heart of the urban core must represent a positive element, one that contributes in a significant way to the economic strength, attractiveness and function of the area. This is a very important factor in all cities, and especially so in the case of the Nation's Capital, where considerable effort has been expended to develop an attractive environment that can be a show place.

The elevated Transitway violates many of the criteria established for urban design and creates a very formidable visual barrier through the heart of the Central Area. Urban design efforts can only try to improve the environment under the facility where the major problem would be the lack of direct sunlight.

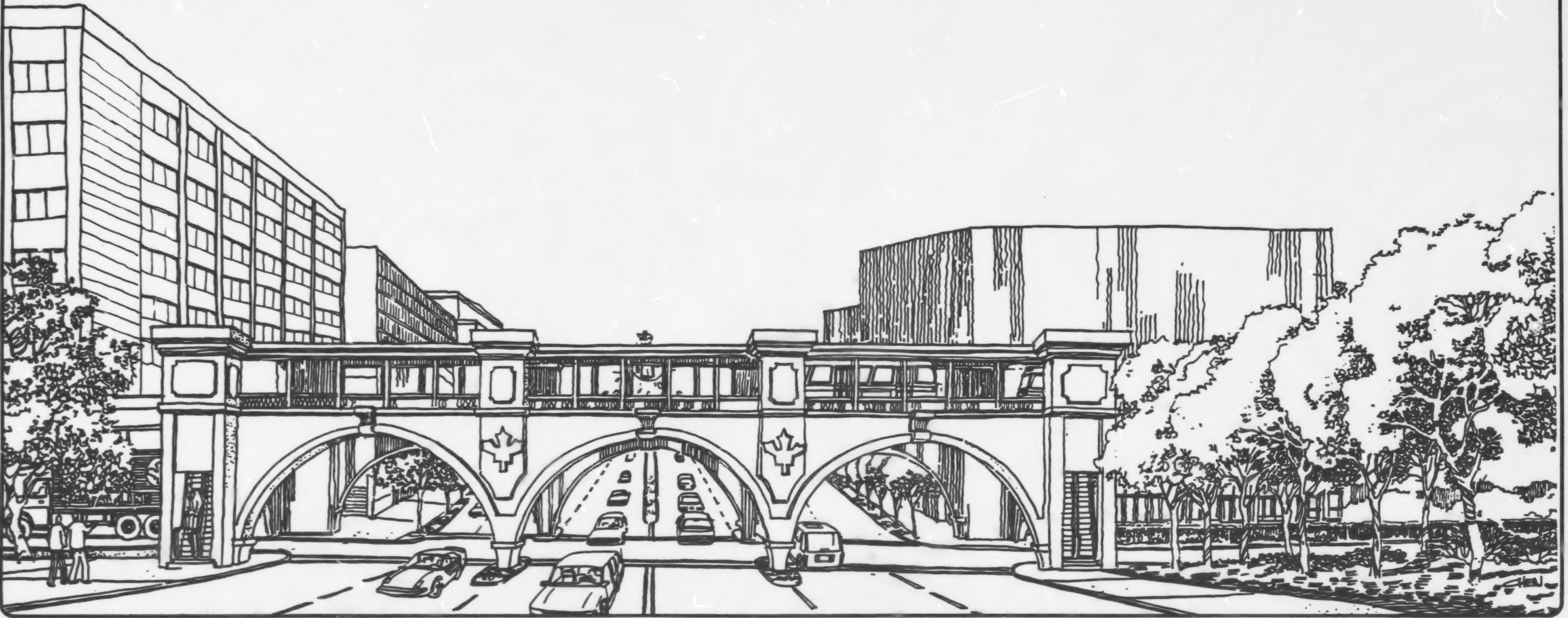
The impact of the facility on adjacent buildings at the third and fourth floor levels cannot be mitigated. The sound walls along the Transitway, the station platform and enclosures will be permanent and physical barriers adjacent to those buildings and in most cases significantly detract from both the exterior attractiveness of the buildings, and the ability of the owner to secure rent levels appropriate to the location. This will produce a permanent loss of assessment value.

The east approaches past the University of Ottawa precinct will also incur significant impact, and this may be felt by the proximity to historic buildings and residences.

The very important section over the Canal, across the northern boundary of the Confederation Park, and across Elgin Street constitutes a formidable urban design challenge. During the investigations various concepts were prepared to test the visual impact across this section. The structure itself has to be large and presents a barrier to the sight lines no matter how beautiful it can be made to look. It was acknowledged that even with an excitingly beautiful concept of a bridge it still would be unacceptable to many people. **See Exhibit 5.12** for an example of a concept prepared when it was contemplated that a low level station at Elgin-Metcalfe could be used. With a high level station as discussed earlier, the bridge elevation is even higher than shown in the exhibit.

At the west end comprehensive efforts, as described earlier, were made to lower the profile, achieve a station at Booth, eliminate the 6 percent grades and preserve the Bronson-Portage connection. The compromise solution resulted in a profile over the proposed Bronson Portage connection and a long elevated structure across Lebreton Flats with a station at Booth Street 15 m in the air. This would constitute a very formidable imposition on the flats area.

EXHIBIT 5.12



REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN / HARRY WEESE & ASSOCIATES

ELEVATED OPTION
BRIDGE OVER ELGIN STREET

## 5.8 Summary and Conclusions

### 5.8.1 Summary

- The preferred elevated Transitway option is a technically feasible option and can be developed with grades, curvature and clearances compatible with the other options.

- The preferred alignment uses Slater Street and the Mackenzie King Bridge crossing of the Canal. It requires a significant intrusion into the DND building.

- The elevated option will improve transit operations through the Central Area over the continued surface operations.

- The Transitway would be subject to interruption of service by fire vehicles responding to emergencies along Slater Street. This would prove to be an unacceptable risk to service levels by OC Transpo.

- The vertical profile requires a 10 metre high deck through the Central Area. At the stations, pedestrian underpasses would be provided at the 6 m level for transit passengers crossing from the north to the south side of Slater Street. The Booth Street station would be 4.5 to 5.0 m above the grade of Booth Street in order to achieve a 3½ percent grade from Lebreton Flats to a station at Lyon Street.

- The support structure at stations will occupy most of the available 18 m wide Slater Street right-of-way in order to provide for the Station platforms and the running lanes. This will allow only the minimum width of platforms and no passing lanes. The lack of passing lanes reduces to operational flexibiity of the Transitway.

- Station construction will require off-street property on both sides of stations at Elgin and Lyon. Bank Street station can be implemented within the street.

- The alignment west of the station at the Rideau Centre will impose very significant impact on the DND building.

- The best structural support would utilize a two column system, which would effectively eliminate one lane from Slater Street.

- The construction of the facility will result in significant disruption to the normal activities along Slater Street. Traffic would be restricted during certain phases of the construction process. During erection of the deck, no through automotive traffic would be permitted. During most other times, at least two lanes would be permitted. Pedestrian access would be maintained, but in a construction environment.

- Impact on urban surroundings and environment is very severe, with a residual negative impact on all property along the corridor.

- Winter operation will require heating of Transitway to avoid snow problems. Heating is known to be a problem for outdoor installations. The alternative is to put a canopy on the system. This would then require ventilation to be provided. The deck of the Transitway would then be unavailable for access by fire vehicles.

- Noise and vibration impacts will require special design features and noise barriers along the structure, thus adding to visual impact.

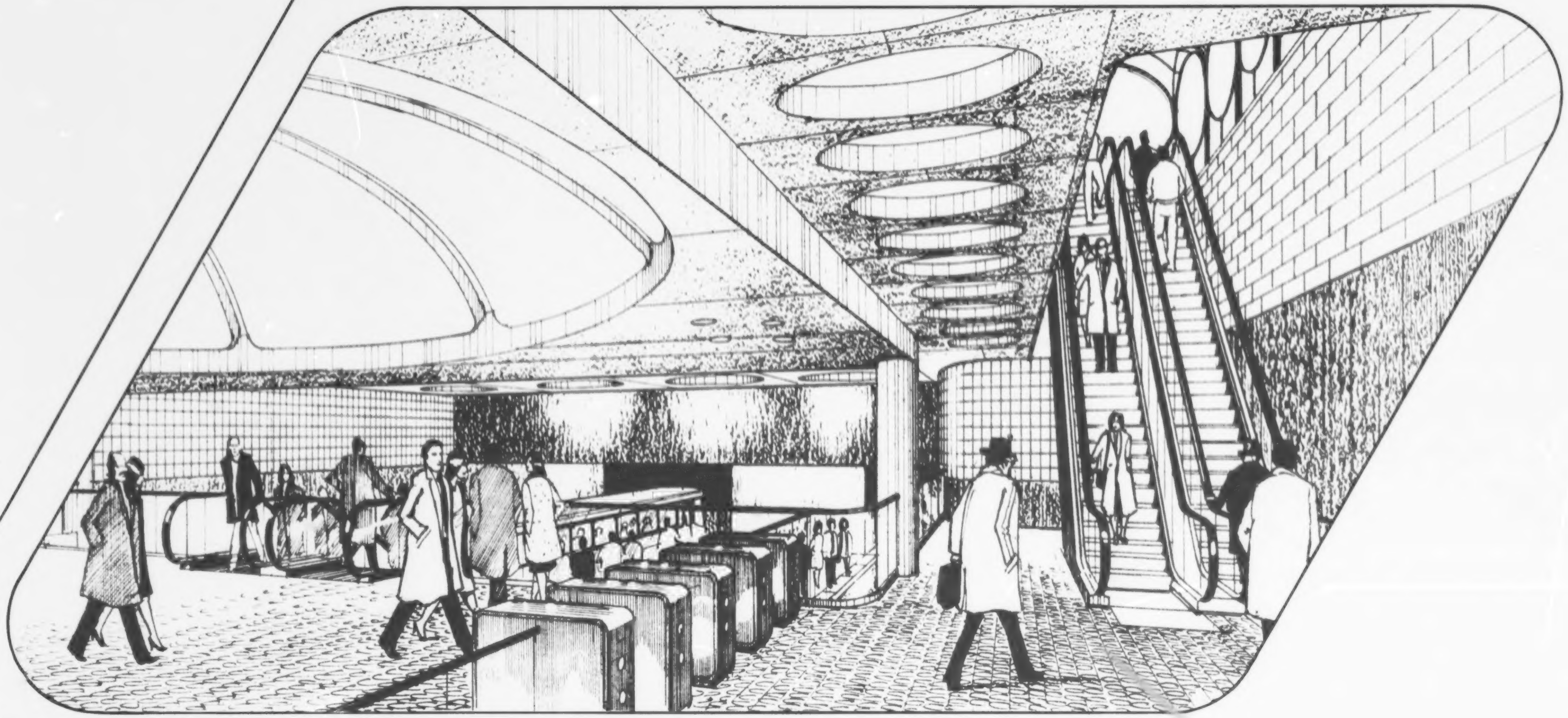
- The life of the exposed structure would be less than the life of the other options which have reduced exposure to the elements.

### 5.8.2 Conclusions

In general, although a technically correct transit solution was found, it was very clear that major impacts were unavoidable. These impacts are primarily on the urban environment along the corridor and the risk to transit operations caused by fire vehicle access and by breakdowns in the cable heating system in the winter. Consultation with the National Capital Commission, the City of Ottawa and OC Transpo during the course of the study confirmed their sensitivity to the impacts. The primary impact is visual. The views up all streets are obstructed and the views in the Elgin Street corridor are significantly impacted. The proximity of the Transitway to building frontages also creates a significant problem for tenants of buildings along the Transitway on Slater Street. Operationally, OC Transpo could not accept unannounced access by fire vehicles, given that there is no opportunity to pass. This issue is critical as is use of the street right-of-way by large construction cranes at various times through the year. If the Elevated section was designed to accommodate the crane loads, it would add significantly to the bulk of the structure and to the visual impact and to the cost.

The station at Booth Street in Lebreton Flats is also a problem due to its height above existing grade. The Transitway through this area presents a visual obstruction to the residential area south of the Transitway.

Although the elevated option can be built it violates almost every environmental-urban design criteria. Operationally it is inferior to the other options and it is concluded that it does not represent a desirable or feasible option. It was not possible during this study, given the constraints, to develop an elevated option that is considered to be a viable option that could be recommended as a serious candidate.



# CHAPTER 6

# 6.0 UNDERGROUND OPTION USING CUT-AND-COVER CONSTRUCTION TECHNIQUE

## 6.1 Introduction

This chapter describes the technical analysis of the cut-and-cover alternatives.

The alternative cut-and-cover concepts are briefly described as is the screening process that produced a shortlist of four concepts. Each of the four concepts is evaluated. The construction techniques for cut-and-cover are described in detail followed by a comparison of the four concepts. The preferred cut-and-cover option - the split option is described in detail.

The "cut-and-cover" construction technique is appropriately named for it involves "cutting" through from the surface of the roadway, supporting the utilities found under the road, until a temporary deck or "cover" can be installed. Once the cover is in place, traffic can be restored to the roadway while construction activity continues under the deck, until the tunnel box structure is completed. The temporary decking is then removed, backfill placed, utilities restored, the road surface reconstructed and the street returned to its original condition. Needless to say, this technique involves considerable street level disruption. Throughout the process, traffic can be maintained on at least two lanes and pedestrian access to buildings would always be maintained. This technique has been used extensively in Toronto, and is being used on a major section of the Seattle downtown bus tunnel project. In most cases this method is used as it has been found, depending upon the sub-surface geology, to be less costly than tunnel boring.

During the first phase of the project a number of potential alignments were developed through the study corridor between Campus Station and Lebreton Station. These various alignments are shown on **Exhibit 6.1.**

For each of the alignments various Transitway/station concepts were possible. These ranged from the conventional side by side running ways with station platforms opposite each other, staggered stations, stations developed one over the other, and finally eastbound travel down one street and westbound travel down a second street - a split option. Various cross sectional arrangements for the transitway lanes, pedestrian connection, platforms and fare collection areas were investigated. Each of these arrangements has some merits and some constraints depending upon other factors such as operation, passenger transfer, fare control, mezzanine development, urban design impact, ability to integrate into existing and proposed development, conflict with utilities, potential disruption during construction, and availability of right-of-way and need to acquire easements for underground sections.

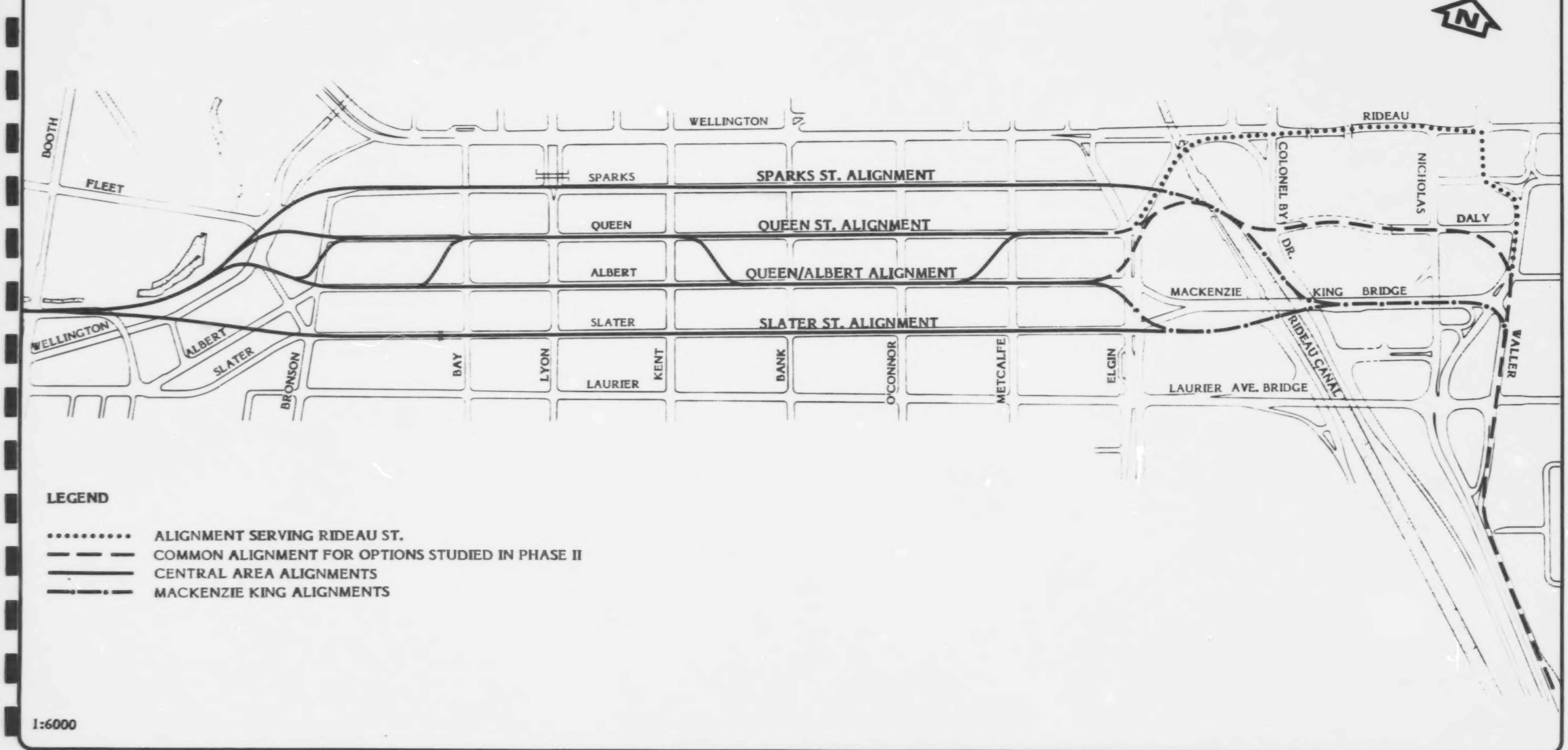
## 6.2 Preliminary Screening of Initial Alternatives

In order to identify the most promising alternatives, the preliminary concepts developed in the first part of the study and shown on **Exhibit 6.1** were subjected to a initial evaulation process. Some of the factors and comments about each alternative are discussed in the following section.

### 6.2.1 Urban Design Issues

The on-street impacts after construction of all cut-and-cover options are relatively minimal in that there are no overhead structures which affect light and view. There are, however, ventilation requirements and the need for exhaust vents at or above street level. The major impact at street level is that of station entrances which require identification and enclosure. The most negative impacts of the cut-and-cover options are the dislocations to existing services and traffic during construction. This involves re-routing of surface traffic during the time period required to place the street decking and to remove it and restore the street surface. There are good opportunities for linkage from the underground stations to existing below grade facilities.

**EXHIBIT 6.1**


N
BOOTH
FLEET
WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
SPARKS ST. ALIGNMENT
QUEEN ST. ALIGNMENT
QUEEN/ALBERT ALIGNMENT
SLATER ST. ALIGNMENT
WELLINGTON
ALBERT
SLATER
BRONSON
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
RIDEAU
COLONEL BY DR.
NICHOLAS
DALY
MACKENZIE KING BRIDGE
RIDEAU CANAL
WALLER
LAURIER AVE. BRIDGE
LEGEND
•••••••••• ALIGNMENT SERVING RIDEAU ST.
— — — COMMON ALIGNMENT FOR OPTIONS STUDIED IN PHASE II
——— CENTRAL AREA ALIGNMENTS
—·—·— MACKENZIE KING ALIGNMENTS
1:6000

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**CUT AND COVER OPTION**
**ALIGNMENT ALTERNATIVES STUDIED**

The urban design issues associated with the various preliminary alignments are listed as follows:

- Canal Alignment

  Any stations along the Canal would not be recommended for visual, access and alignment reasons.

- Confederation Square

  In terms of the potential disruption during construction to Confederation Square any alignment should try to avoid this park.

- Mackenzie King/Slater

  This alignment would be acceptable. As this alignment passes below the Canal it becomes "deep tunnel" and has an impact on the depth of the station at the Rideau Centre. This alignment may pass under the NAC parking garage although this can be avoided by introducing additional curvature.

- Rideau Street Alignment

  This alignment passes through a sensitive area. It would likely be difficult to find adequate design solutions for stations in the vicinity of the Daly Building, given the restricted sidewalk space.

- Sparks Street Alignment

  This alignment would have an impact on the pedestrian environment of this precinct during construction. There is however the obvious benefit of minimal disruption to vehicular traffic. Sparks Street is probably too far north to adequately serve the core area.

- Queen Street Alignment

  Relatively speaking, disruption is fairly minimal along this alignment. Queen Street may be considered too far north to adequately serve the core area. The blocks bounded by Albert and Queen are the best in terms of station location and have good potential for integration with both existing and future development.

- Queen/Albert Alignment and Albert/Slater Alignment

  Alignments on these streets are favoured because they give the best station coverage of the Central Area. The potential for station integration is good, either within street or on undeveloped sites. The split alignments present additional opportunities to spread out the station access points.

### 6.2.2 Operations Factors

From the viewpoint of operations and transit service levels, the alignments along Queen and Albert, or Albert and Slater provide good service to the core, with the Albert and Slater alignment favoured slightly. There are good opportunities to develop station access points along any of the corridors. Station integration potential for any of the alignments was considered good, and would in the final analysis depend upon the degree of integration desired for a station. Fare control would also be a function of station planning and this could be accommodated at any station.

The major factor affecting operations would be the period of implementation when street use would be restricted. This would definitely be a significant negative factor, particularly if the split concept were selected. However, with the split alternative, it is possible to have less disruption on any one street at one time. During construction, bus service must continue to be operational, reliable and effective. With this construction technique delays are inevitable and will present severe operational problems for OC Transpo as well as all other street traffic.

### 6.2.3 Other Factors

The utility impacts are obviously less when a single street is selected. An alignment on Slater Street was less favourable due to major sewer facilities. Albert Street, opposite the Bell Telephone Building would also be a major concern because of the very large underground telephone cable duct work. Other under street obstructions included the parking garage ramp from the NAC exiting into Queen Street, and the Place de Ville facilities beneath Queen Street.

Another major factor to be considered is the narrow right-of-way available on Albert, Slater and Queen streets. The width requirements of some of the options would require construction activity within a metre or so of the building foundations. Extension under existing buildings with significant additional costs and risks would also be required if the transitway was to use only one street.

From the fourteen (14) preliminary alignments investigated in the initial phase of the study, four (4) alignments were retained for more detailed technical analysis. These options are described in the following section and are:

- the "split" alternative using a single direction of travel on both Queen Street and Albert Street;
- the "staggered" alternative on either Queen Street or Albert Street;
- the "side-by-side" alternative on either Queen Street or Albert Street;
- the "over/under" alternative on Queen Street or Albert Street.

All these alternatives follow a common alignment from Campus Station, proceding north of the NAC, onto Daly Street, and through the Rideau Centre.

The detailed technical analysis carried out for these alternatives included:

- the development of typical stations including cross-sections and locations;
- the development of plans and profiles for each of the options;
- the further analysis of utility relocation/construction;
- method and staging of construction including street availability and need for traffic diversions;
- preliminary construction costing of the major civil works.

Station integration with existing and proposed development was explored and concepts developed which demonstrated in a representative fashion, some potential street entrance possibilities.

## 6.3 General Discussion of the Detailed Investigation of the Four Alternatives

### 6.3.1 General Description of Alternatives

The four alternatives developed in conjunction with the use of the cut-and-cover method of construction are:

(a) Split Alignment on Queen and Albert Street

This alternative has a one-lane structure for eastbound traffic beneath Queen Street and a one-lane structure for westbound traffic beneath Albert Street. At stations, the platforms are joined by a passageway along the cross streets between Queen Street and Albert Street.

(b) Staggered Alternative on Queen or Albert Street

The staggered alternative has the eastbound and westbound station platforms separated along the route with a mezzanine above and between them. The route for this alternative and the following two alternatives can be on either Queen Street or Albert Street.

(c) Side by Side Alternative on Queen or Albert Street

This is the conventional station design with platforms opposite each other and with a mezzanine above. Either Queen or Albert Street can be used for this alternative.

(d) Over and Under Alternative on Queen or Albert Street

In this alternative, single lane structures are placed one on top of the other. At stations, the structures widen for platforms and a mezzanine is placed above the top structure. Again, either Albert or Queen Street can be used.

### Depth of Structures/Utility Relocation

Profiles of all four alternatives show a minimum of 2.4 metres between the top of the structure and the existing street elevation. This depth to the structure is intended to allow for existing utilities, such as gas, water, electrical (hydro), telephone ducts to be maintained or replaced during construction in their existing locations. However, it does not provide for sewers of a greater depth than 2.4 metres which would have to be relocated or, for the smaller sewers, reconstructed using siphons. Where the proposed structure is in conflict with an existing sewer, relocation or reconstruction is often less expensive than lowering the entire structure.

As an alternative to relocation or reconstruction of the sewers along the north-south crossing streets for the 'split' option, an alternative vertical alignment was developed that lowered the main transit structure below the north-south sewers.

### Horizontal Curve Considerations

All four alternatives were developed to suit the initial proposed use of buses with provision for future conversion to Rail Transit. The sharpest curve used was 90 metres radius.

### Profile Considerations

A 3.5 percent upgrade was the maximum grade allowed, although short sections of 6 percent downgrade were considered to be acceptable.

### Station Design Considerations

Station concepts were developed with the objective of achieving the following:

- a mezzanine or control area that would allow for fare collection and multiple street access either through sidewalk entrances or entrances through adjacent buildings;
- a minimum platform width of 4.2 metres with potential for a 6 m station at key areas, and platform length of 110 metres;
- a minimum of one escalator and one stair for access from the mezzanine to each platform, and the provision of one elevator;
- a provision for a bus passing lane as well as a platform to allow passing a bus that has broken down; and
- a station structure that can be constructed within the nominal existing right-of-way of 18.0 metres from street line to street line.

### 6.3.2 East End Alignment

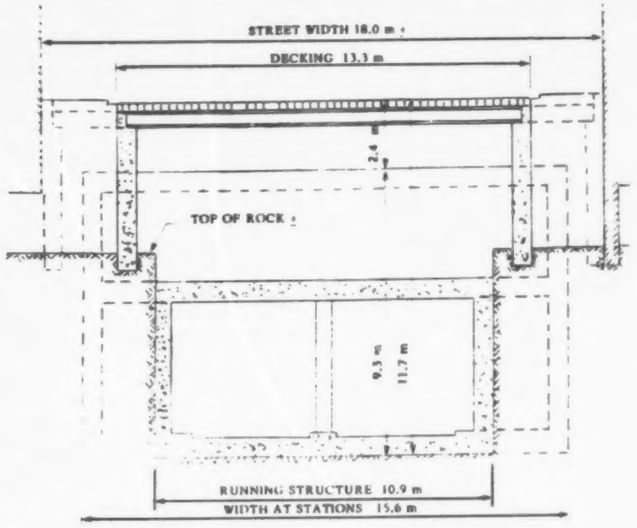
All four alternatives have a common alignment in this part of the route between Campus Station and the Canal as shown on **Exhibit 6.1.**

The route, begins at the end of the existing busway, near Campus Station and runs in the open to a portal on Waller Street, south of Laurier Avenue where it goes underground. It proceeds north beneath Waller Street to Daly Avenue where it turns on a 90 metre radius curve to go west under Daly Avenue and through to the Rideau Centre. The busway then crosses under the Rideau Canal north of the National Arts Centre to a point near Elgin Street.

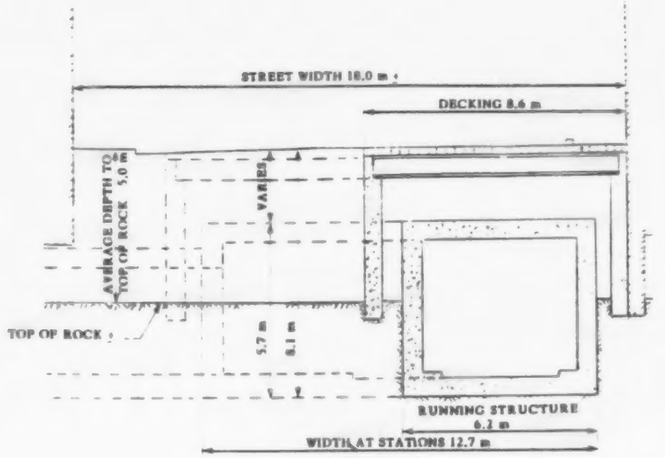
The running structure for the East End Alignment Section from Campus to Rideau Centre Station is two lanes wide and built of reinforced concrete as shown on **Exhibit 6.2.** It is 10.9 metres wide, 5.7 metres high and varies in depth below the surface.

The proposed station at the Rideau Centre is under Daly Avenue west of Nicholas Street and is illustrated on **Exhibit 6.3.** The station platforms are 110 metres long and 4.2 metres wide. A centre passing lane is shown at this station and it will be necessary to expand below the adjacent buildings to provide the required station width. The mezzanine and control area are located west of the station platforms and one level above with stairs and escalators connecting the mezzanine to the platforms. The Rideau Centre is connected to the mezzanine by stairs, escalators and elevator. **Exhibit 6.3** shows the elevations of the various levels in this station.

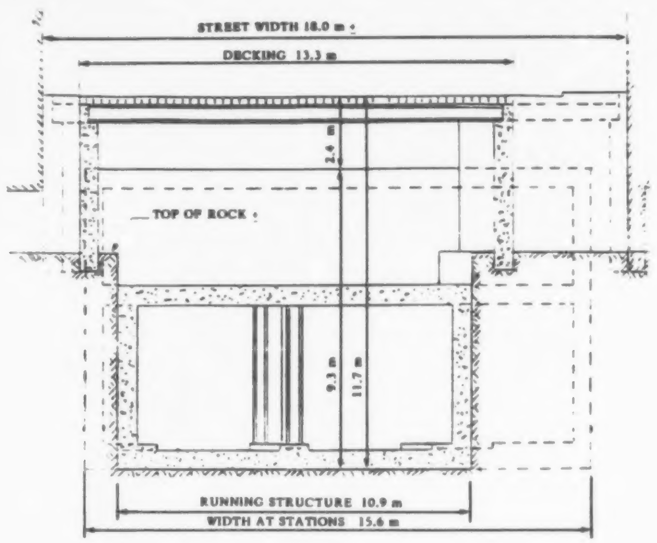
**EXHIBIT 6.2**


STREET WIDTH 18.0 m ±
DECKING 13.3 m
2.4 m
TOP OF ROCK ±
9.3 m
11.7 m
RUNNING STRUCTURE 10.9 m
WIDTH AT STATIONS 15.6 m

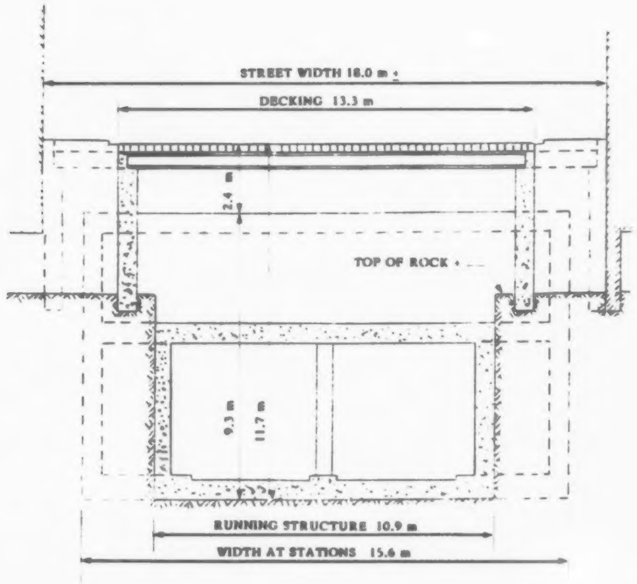
**EAST END ALIGNMENT**


STREET WIDTH 18.0 m ±
DECKING 8.6 m
AVERAGE DEPTH TO TOP OF ROCK 5.0 m
VARIES
TOP OF ROCK ±
5.7 m
8.1 m
RUNNING STRUCTURE 6.2 m
WIDTH AT STATIONS 12.7 m

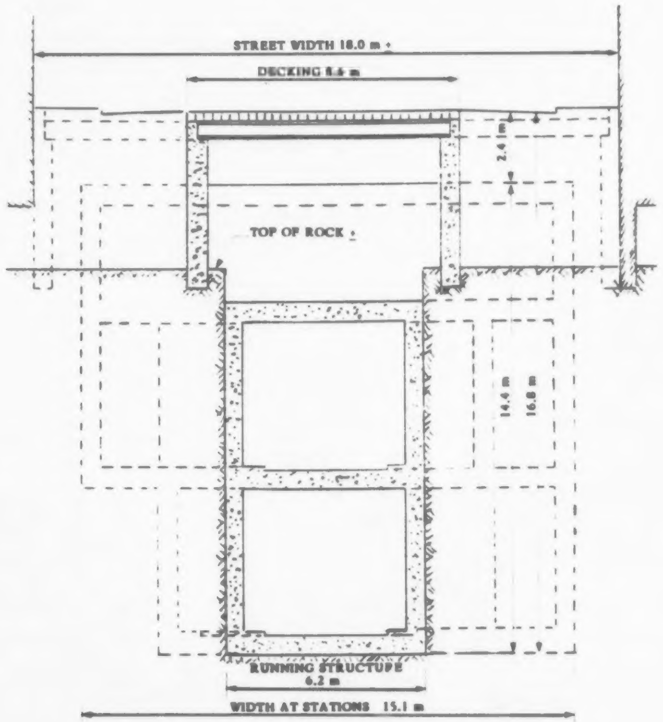
**SPLIT CONCEPT**


STREET WIDTH 18.0 m ±
DECKING 13.3 m
2.4 m
TOP OF ROCK ±
9.3 m
11.7 m
RUNNING STRUCTURE 10.9 m
WIDTH AT STATIONS 15.6 m

**STAGGERED CONCEPT**


STREET WIDTH 18.0 m ±
DECKING 13.3 m
2.4 m
TOP OF ROCK ±
9.3 m
11.7 m
RUNNING STRUCTURE 10.9 m
WIDTH AT STATIONS 15.6 m

**SIDE BY SIDE CONCEPT**


STREET WIDTH 18.0 m ±
DECKING 8.6 m
2.4 m
TOP OF ROCK ±
14.4 m
16.8 m
RUNNING STRUCTURE 6.2 m
WIDTH AT STATIONS 15.1 m

**OVER/UNDER CONCEPT**

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

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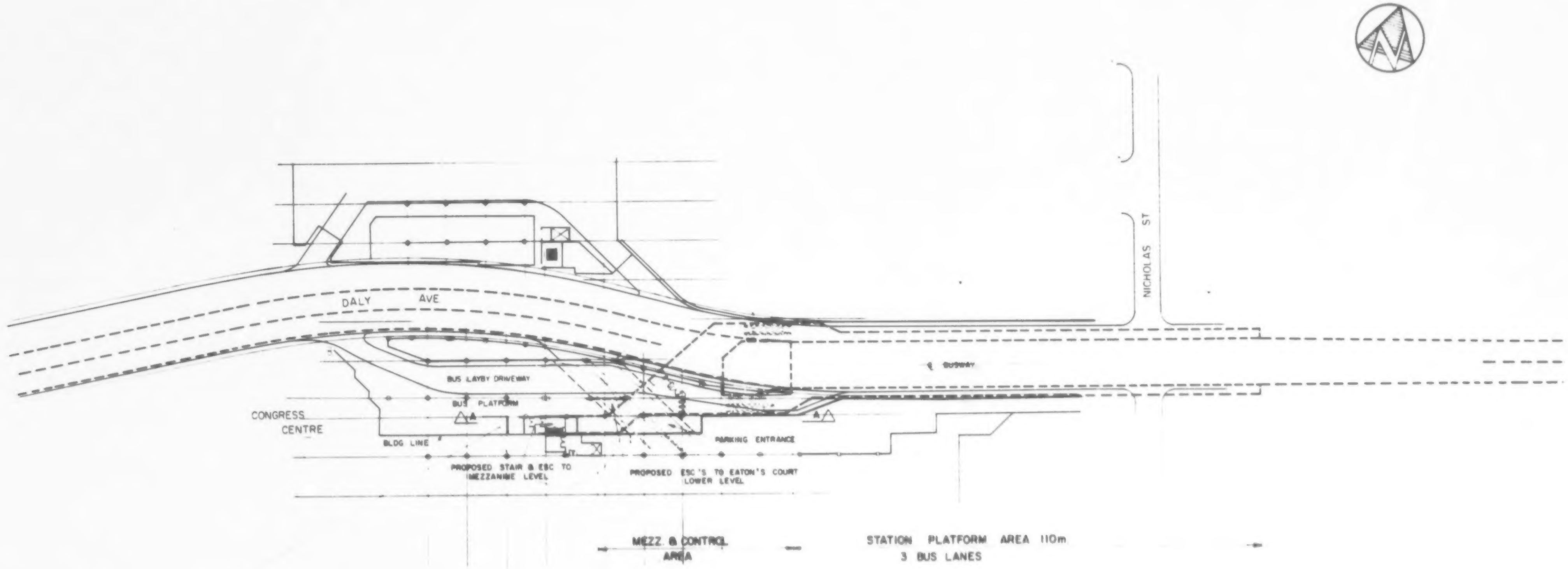
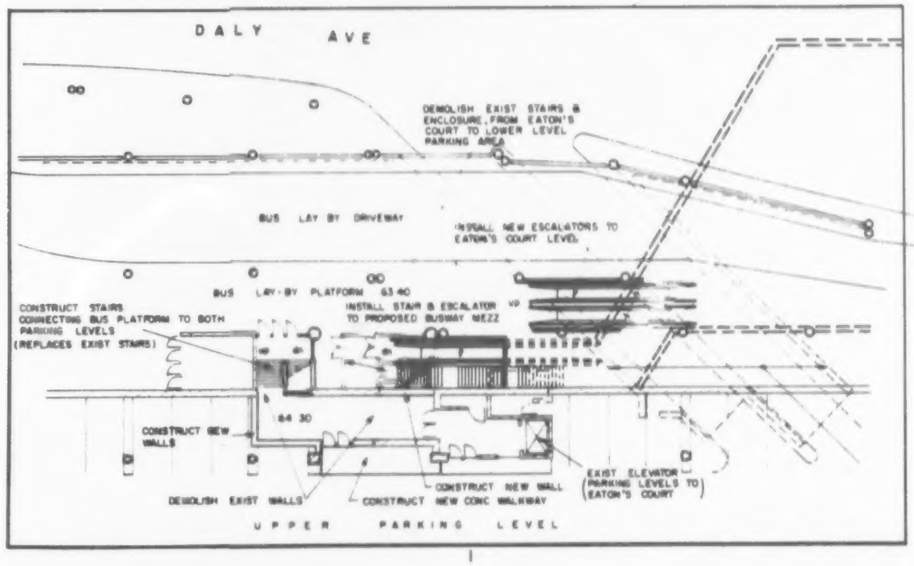
## CUT AND COVER OPTION TYPICAL CONSTRUCTION AND DECKING CROSS-SECTIONS

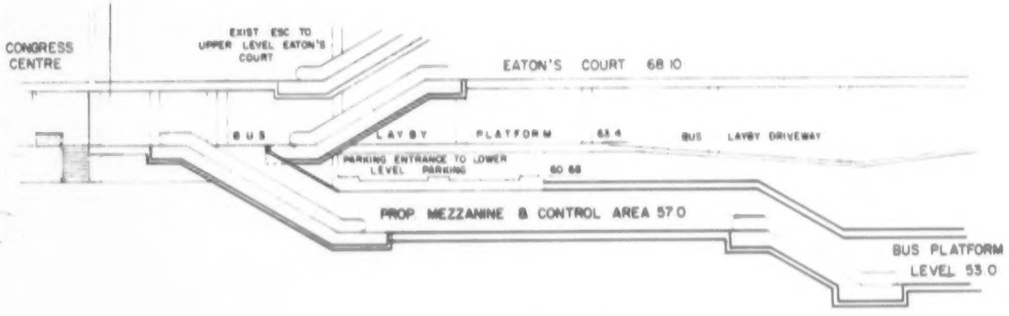
## EXHIBIT 6.3


DALY AVE
NICHOLAS ST
℄ BUSWAY
BUS LAYBY DRIVEWAY
BUS PLATFORM
CONGRESS CENTRE
BLDG LINE
PARKING ENTRANCE
PROPOSED STAIR & ESC TO MEZZANINE LEVEL
PROPOSED ESC'S TO EATON'S COURT LOWER LEVEL
MEZZ. & CONTROL AREA
STATION PLATFORM AREA 110m
3 BUS LANES

PLAN


DALY AVE
DEMOLISH EXIST STAIRS & ENCLOSURE, FROM EATON'S COURT TO LOWER LEVEL PARKING AREA
BUS LAY BY DRIVEWAY
INSTALL NEW ESCALATORS TO EATON'S COURT LEVEL
BUS LAY-BY PLATFORM 63.40
CONSTRUCT STAIRS CONNECTING BUS PLATFORM TO BOTH PARKING LEVELS (REPLACES EXIST STAIRS)
INSTALL STAIR & ESCALATOR TO PROPOSED BUSWAY MEZZ
UP
64.30
CONSTRUCT NEW WALLS
DEMOLISH EXIST WALLS
CONSTRUCT NEW WALL
CONSTRUCT NEW CONC WALKWAY
EXIST ELEVATOR (PARKING LEVELS TO EATON'S COURT)

UPPER PARKING LEVEL


CONGRESS CENTRE
EXIST ESC TO UPPER LEVEL EATON'S COURT
EATON'S COURT 68.10
BUS LAYBY PLATFORM 63.4
BUS LAYBY DRIVEWAY
PARKING ENTRANCE TO LOWER LEVEL PARKING
60.68
PROP MEZZANINE & CONTROL AREA 57.0
BUS PLATFORM LEVEL 53.0

SECTION A-A

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN** / T.T.C.L.

## CUT AND COVER OPTION
## RIDEAU CENTRE STATION CONCEPT

### 6.3.3 Split Alternative Alignment

West of Elgin Street, the split alternative separates into eastbound and westbound facilities. A single lane structure for eastbound traffic proceeds beneath Queen Street. A single lane structure for westbound traffic turns south one block and then proceeds beneath Albert Street. The structures run underground beneath the respective streets until they exit to the surface at portals west of Bronson Avenue. Just beyond the portals the lanes come together and run in the open until they join the existing Transitway at Booth Street. The split alternative also crosses the lanes over to achieve centre platform type operation through the Central Area. The crossover occurs just east of Elgin Street, and in the west just to the east of the old waterworks site. This is explained in more detail in a later section of this chapter.

Typical single lane structures as would be used under Albert or Queen Street are shown on **Exhibit 6.2** (Split concept). They are 6.2 metres wide and 5.7 metres high. The invert is at varying depths below the road surface depending upon location and station design.

Stations are located at Metcalfe Street, Bank Street and Bay Street. **Exhibit 6.4** illustrates a functional layout for a typical split station. Platforms are 110 metres long and 4.2 metres wide. No mezzanine is required above the platforms. This allows the station platforms to be kept at a minimum depth. The platforms are connected by passageways containing fare collection facilities along the cross-streets between Queen Street and Albert Street. Stairs, escalators and elevators are provided from this passageway level to adjacent buildings and the surface.

To avoid conflict with north-south sewers (Bank Street and Kent Street) and building tunnels under Queen Street at Place de Ville, increased depth of the Transitway is required.

Summary of 'split' alternative features:

- minimum platform width 6.0 metres is achievable, within the street right-of-way;
- two bus lanes are provided at each platform, thus providing a passing lane through the station;
- multiple street access can be made to the control area passageway at platform level on the cross streets;
- the total running and station structure can be constructed within the 18.0 metre street allowance; and
- increased depth of the structure is required to avoid large utilities and existing under-street tunnels.

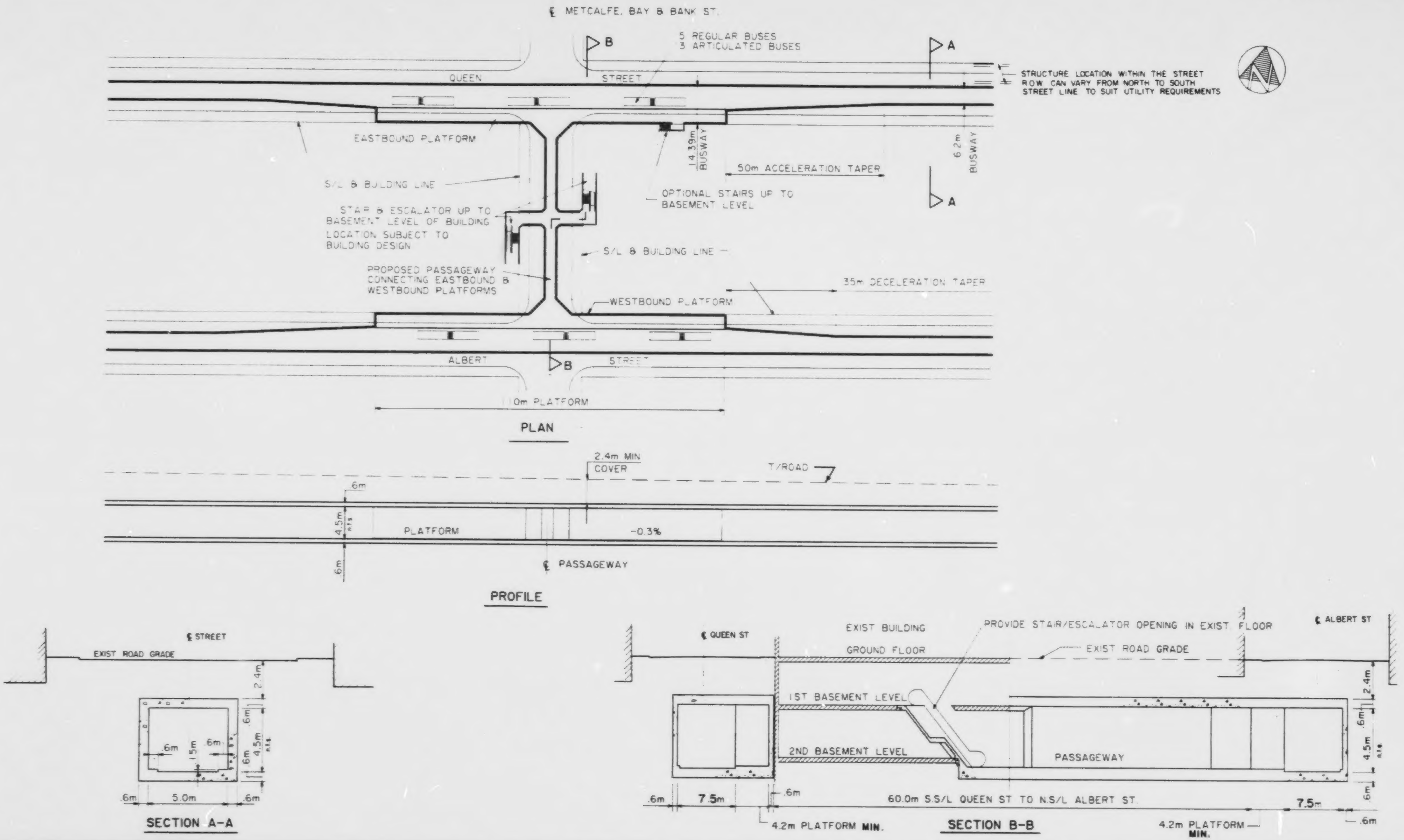
### 6.3.4 Staggered Alternative

From the common point where the east end alignment ends, this alternative proceeds westward beneath Queen Street or Albert Street. The underground structure exits at a portal west of Bronson Avenue and proceeds in the open between retaining walls to meet the existing busway.

The running structure for this option is a two-lane reinforced concrete box 10.9 metres wide, 5.7 metres high and about 10 metres below the surface. **Exhibit 6.2** (Staggered concept) illustrates the concept cross section.

Stations are located at Metcalfe Street, Bank Street and Bay Street and a typical station is shown on **Exhibit 6.5**. As illustrated, the station platforms are staggered with a mezzanine above and between the platforms. These stations have platforms 110 metres long and 2.5 metres wide. Escalators and stairs connect the mezzanine to the platforms. However, there is only room to construct one stair or escalator at the end of the platforms within the 18.0 metre right-of-way. Additional property (a sub-surface easement) would be required to provide the second stair or escalator to each platform or to increase the width of the platforms.

**EXHIBIT 6.4**

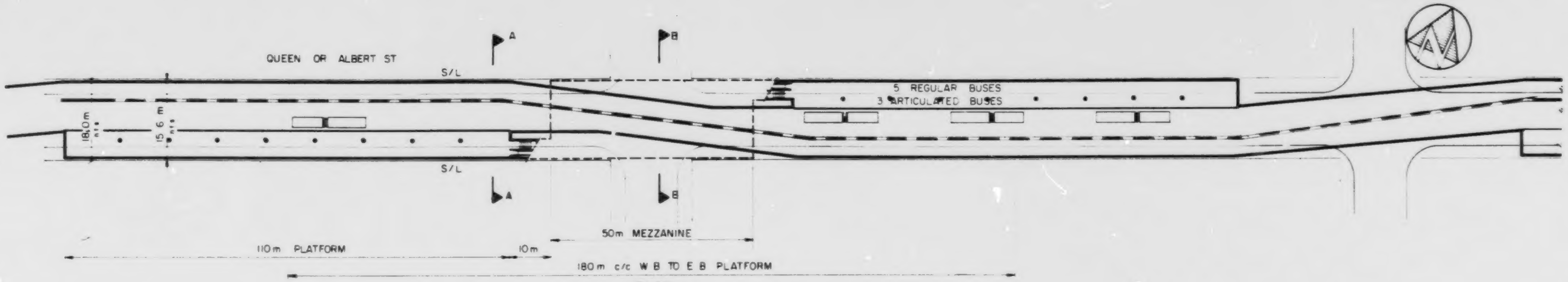

℄ METCALFE, BAY & BANK ST.
B
5 REGULAR BUSES
3 ARTICULATED BUSES
A
STRUCTURE LOCATION WITHIN THE STREET R.O.W. CAN VARY FROM NORTH TO SOUTH STREET LINE TO SUIT UTILITY REQUIREMENTS
QUEEN STREET
EASTBOUND PLATFORM
14.39m BUSWAY
6.2m BUSWAY
50m ACCELERATION TAPER
S/L & BUILDING LINE
STAIR & ESCALATOR UP TO BASEMENT LEVEL OF BUILDING
LOCATION SUBJECT TO BUILDING DESIGN
OPTIONAL STAIRS UP TO BASEMENT LEVEL
A
S/L & BUILDING LINE
PROPOSED PASSAGEWAY CONNECTING EASTBOUND & WESTBOUND PLATFORMS
35m DECELERATION TAPER
WESTBOUND PLATFORM
ALBERT STREET
B
110m PLATFORM
PLAN
2.4m MIN COVER
T/ROAD
.6m
4.5m n.t.s.
PLATFORM
-0.3%
.6m
℄ PASSAGEWAY
PROFILE
℄ STREET
EXIST ROAD GRADE
2.4m
.6m
.6m
.15m
.6m
.6m
4.5m n.t.s.
.6m
5.0m
.6m
SECTION A-A
℄ QUEEN ST
EXIST BUILDING
GROUND FLOOR
PROVIDE STAIR/ESCALATOR OPENING IN EXIST. FLOOR
EXIST ROAD GRADE
℄ ALBERT ST
1ST BASEMENT LEVEL
2ND BASEMENT LEVEL
PASSAGEWAY
2.4m
.6m
4.5m n.t.s.
.6m
.6m
7.5m
.6m
60.0m S.S/L QUEEN ST TO N.S/L ALBERT ST.
7.5m
.6m
4.2m PLATFORM MIN.
SECTION B-B
4.2m PLATFORM MIN.

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

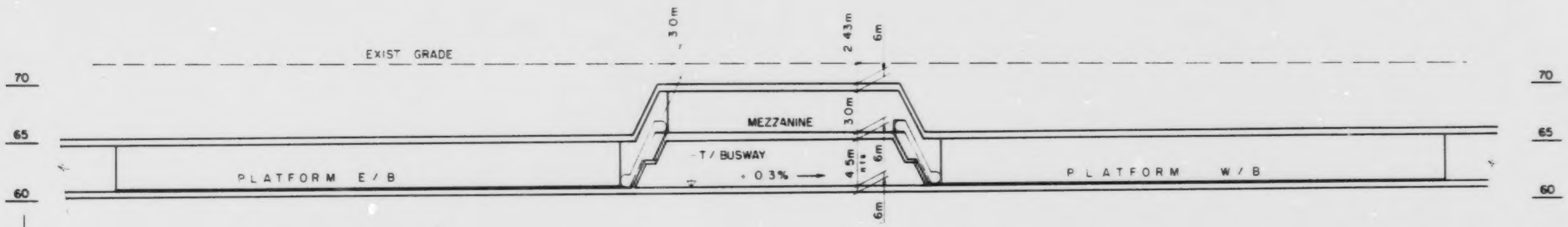
**DELCAN** /T.T.C.L.

## CUT AND COVER OPTION
## TYPICAL STATION LAYOUT
## FOR SPLIT CONCEPT

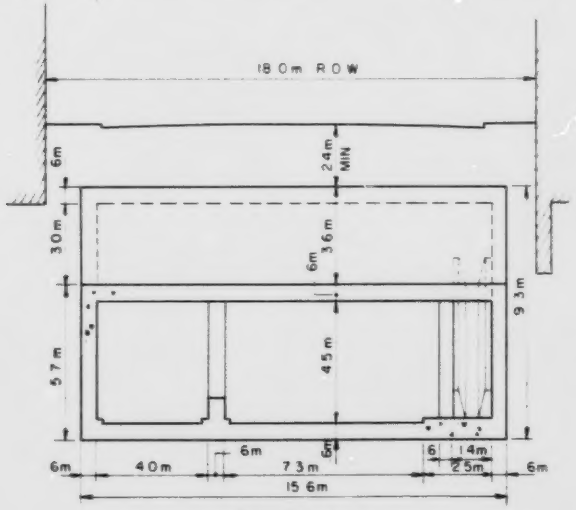
**EXHIBIT 6.5**


QUEEN OR ALBERT ST
S/L
A
B
18,0m nts
15 6m nts
5 REGULAR BUSES
3 ARTICULATED BUSES
S/L
A
B
50m MEZZANINE
110m PLATFORM
10m
180m c/c W B TO E B PLATFORM

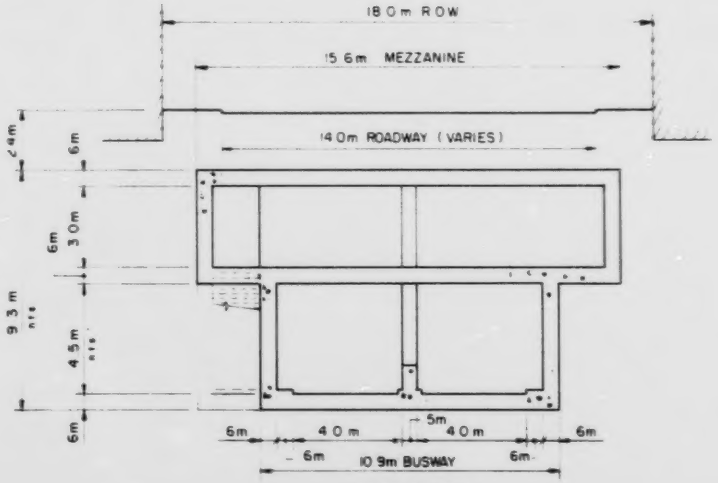
PLAN


3 0m
2 43m
6m
EXIST GRADE
70
65
60
MEZZANINE
3 0m
T / BUSWAY
+ 0 3%
4 5m nts
6m
PLATFORM E / B
PLATFORM W / B
70
65
60

PROFILE
HOR 1 : 500
VER 1 : 200


18 0m ROW
6m
24m MIN
3 0m
3 6m
6m
5 7m
4 5m
9 3m
6m
6m
4 0m
7 3m
6
1 4m
2 5m
6m
15 6m

SECTION A-A


18 0m ROW
15 6m MEZZANINE
14 0m ROADWAY (VARIES)
2 4m
6m
6m
3 0m
9 3m nts
4 5m nts
6m
6m
4 0m
5m
4 0m
6m
6m
10 9m BUSWAY
6m

SECTION B-B

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

**DELCAN** / T.T.C.L.

## CUT AND COVER OPTION
## TYPICAL STATION LAYOUT
## FOR STAGGERED CONCEPT

Summary of 'staggered option station features:

- Platform width 2.5 metres - requires additional property easement for the full length of the platforms to meet the minimum 4.2 metre platform.
- Two lanes are provided at each platform, thus providing a passing lane.
- Only one stair or escalator can be provided at the end of the platforms within the 18.0 metre right-of-way to connect the mezzanine to the platforms. Thus, additional property is required for the second stair or escalator. If the 'passing' bus lane is eliminated then the platform width can be increased and the additional stair or escalator provided within the 18.0 metre right-of-way, provided that the stair and escalator are both located at the end of the platform.

### 6.3.5 Side-by-Side Alternative

This option proceeds from the common point near Elgin Street westbound beneath Queen Street or Albert Street. The route comes into the open at a portal west of Bronson Avenue and proceeds on to the existing busway.

The two-lane reinforced concrete running structure used in this option is shown on **Exhibit 6.2** (side by side). It is 10.9 metres wide, 5.7 metres high and a minimum of 11.7 metres below the surface.

The three stations are located in the same areas as in the previous alternatives and a typical side by side station is shown on **Exhibit 6.6. Exhibit 6.6** illustrates a 3 lane station. This is the conventional type station with platforms opposite each other and with a 50 metre long mezzanine above the platforms. The platform length is 110 metres and its width 3.4 metres. Stairs and escalators run from the mezzanine to the platforms. For the three lane alternative additional property would be required for the length of the platforms to accommodate a minimum 4.2 metre width platform.

Only one escalator or stair is shown connecting the mezzanine to the platform. Thus, to provide the required second stair or escalator, additional property would be required.

Summary of 'side by side' option station features:

- Platform width 3.45 metres - requires additional property for the full length of the platforms to meet the minimum 4.2 metre platform.
- Additional property required to provide the third (passing) lane.
- Difficult to control passengers from crossing Transitway at stations.
- Only one stair or escalator can be provided within the 18.0 metre right-of-way to connect the mezzanine to the platforms. Thus, additional property is required for the second stair or escalator.
- A two lane station (Section C-C on **Exhibit 6.6)** would fit the 18 m row but platforms could only be 3.45 m without additional property.

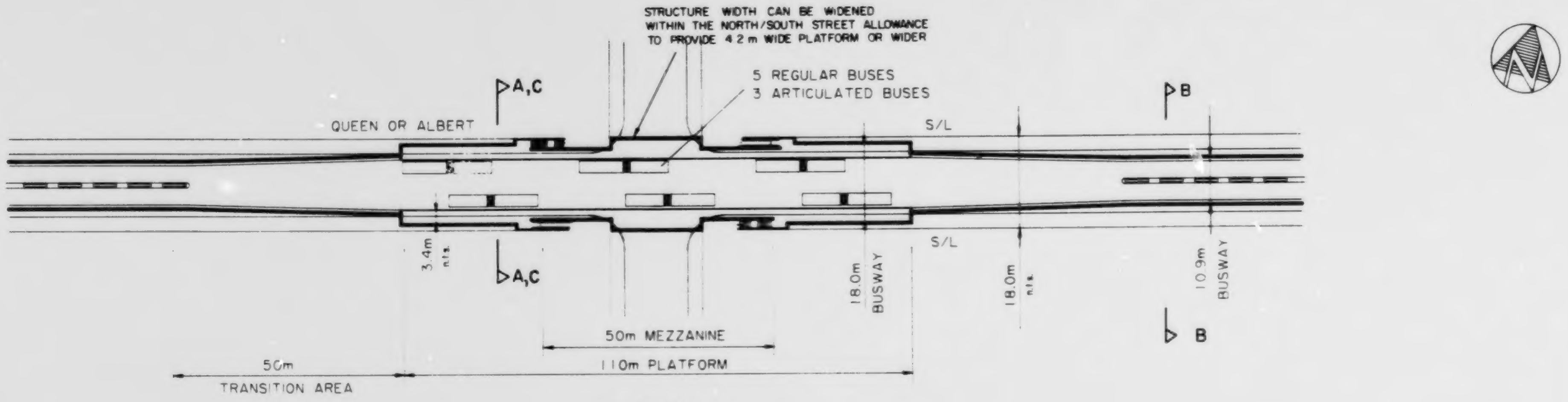
### 6.3.6 Over and Under Alternative

As in the other options, the route here is from the common point near Elgin Street, beneath Queen Street or Albert Street, to a portal west of Bronson Avenue and then to the existing busway.

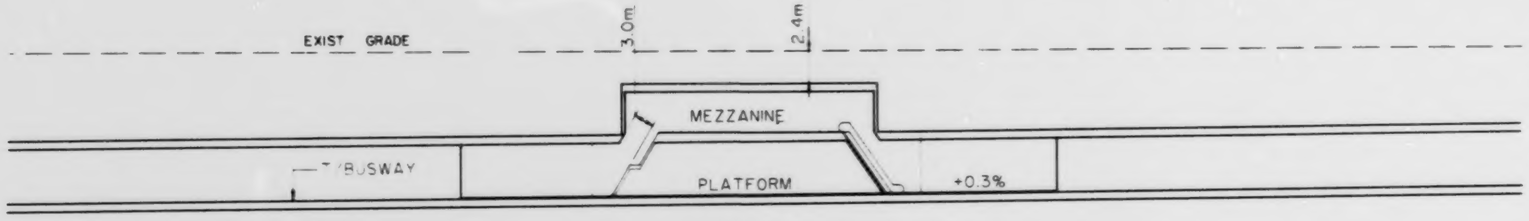
**Exhibit 6.2** (over/under) illustrates the over and under concept. Two single lane reinforced concrete structures are built one on top of the other which carry the traffic in opposite directions. The boxes are each 6.2 metres wide and 5.7 metres high. The invert of the lower box is about 16 metres below the surface. The structure changes from the standard two-lane, side by side, box west of the Canal to the over and under concept. It then changes back from over and under to the conventional two-lane structure just before the portal in the west end.

Again, there are three stations in the same locations. **Exhibit 6.7** shows a typical over and under station with the structures widened to provide a

## EXHIBIT 6.6


STRUCTURE WIDTH CAN BE WIDENED WITHIN THE NORTH/SOUTH STREET ALLOWANCE TO PROVIDE 4.2 m WIDE PLATFORM OR WIDER
5 REGULAR BUSES
3 ARTICULATED BUSES
A,C
B
QUEEN OR ALBERT
S/L
S/L
3.4m n.t.s.
A,C
18.0m BUSWAY
18.0m n.t.s.
10.9m BUSWAY
B
50m MEZZANINE
50m
TRANSITION AREA
110m PLATFORM

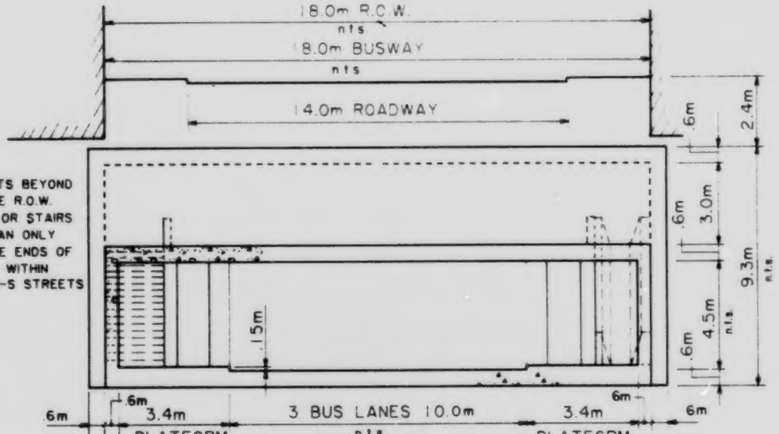
PLAN


EXIST GRADE
3.0m
2.4m
MEZZANINE
T/BUSWAY
PLATFORM
+0.3%

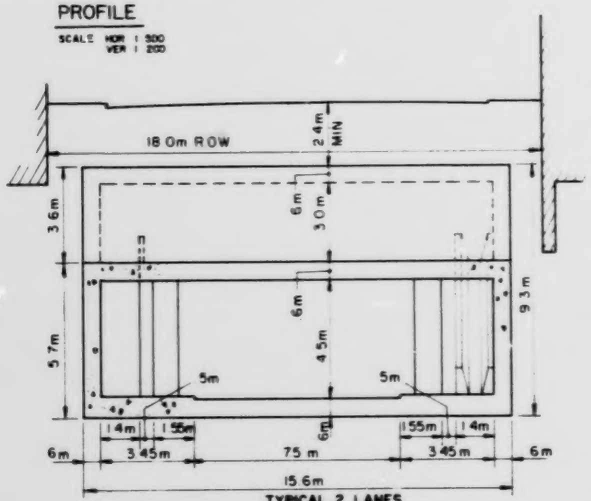
PROFILE

SCALE HOR 1:500
VER 1:200

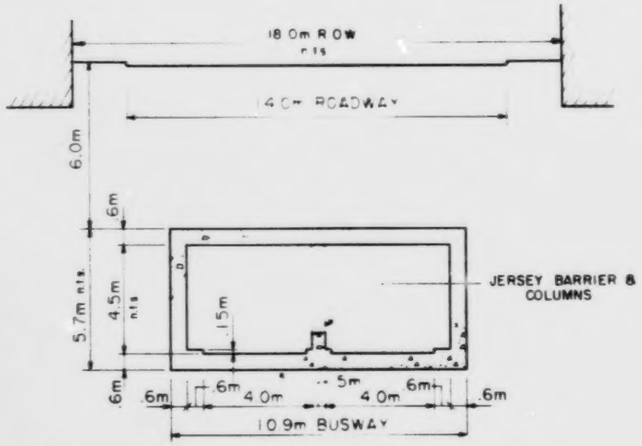
NOTE
STRUCTURE PROJECTS BEYOND STREET LINE.PRIVATE R.O.W. MUST BE OBTAINED OR STAIRS AND ESCALATORS CAN ONLY BE LOCATED AT THE ENDS OF THE PLATFORMS OR WITHIN THE ROW OF THE N-S STREETS


18.0m R.O.W.
n.t.s.
18.0m BUSWAY
n.t.s.
14.0m ROADWAY
.6m
2.4m
.6m
3.0m
9.3m n.t.s.
4.5m n.t.s.
.6m
.15m
.6m
.6m
3.4m
3 BUS LANES 10.0m
n.t.s.
3.4m
6m
.6m
PLATFORM n.t.s.
PLATFORM n.t.s.

TYPICAL 3 LANES
SECTION A-A


18.0m ROW
2.4m MIN
3.6m
.6m
3.0m
5.7m
.6m
4.5m
9.3m
.5m
.5m
1.4m
1.55m
1.55m
1.4m
.6m
6m
3.45m
7.5 m
3.45m
6m
15.6m

TYPICAL 2 LANES
SECTION C-C

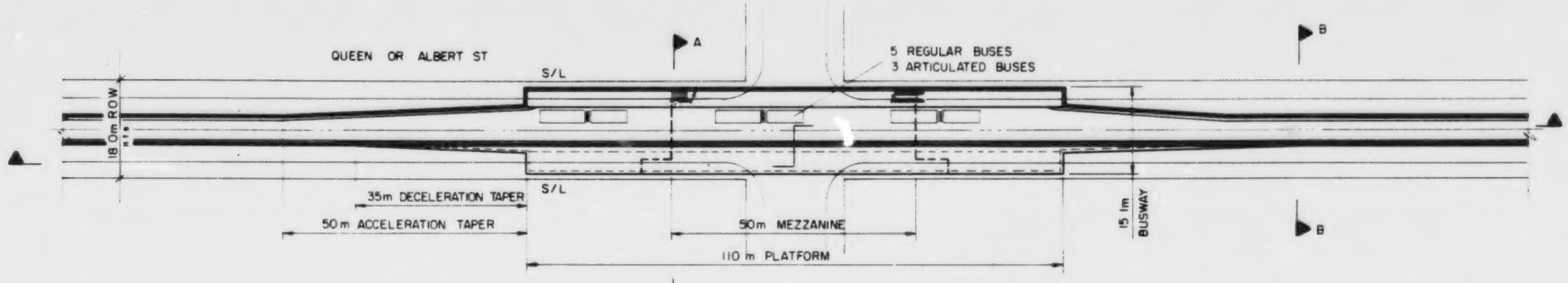

18.0m ROW
n.t.s.
14.0m ROADWAY
6.0m
.6m
5.7m n.t.s.
4.5m n.t.s.
.15m
JERSEY BARRIER & COLUMNS
.6m
.6m
.6m
4.0m
.5m
4.0m
.6m
.6m
10.9m BUSWAY

SECTION B-B

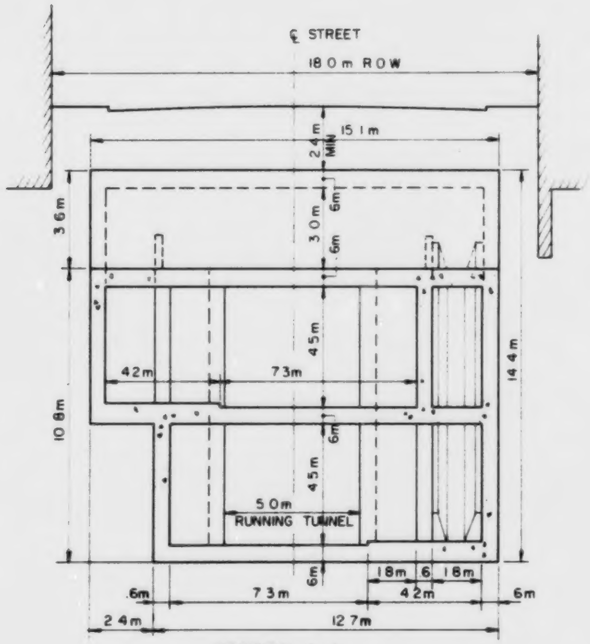
**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN** / T.T.C.L.

**CUT AND COVER OPTION**
**TYPICAL STATION LAYOUT**
**FOR SIDE BY SIDE CONCEPT**

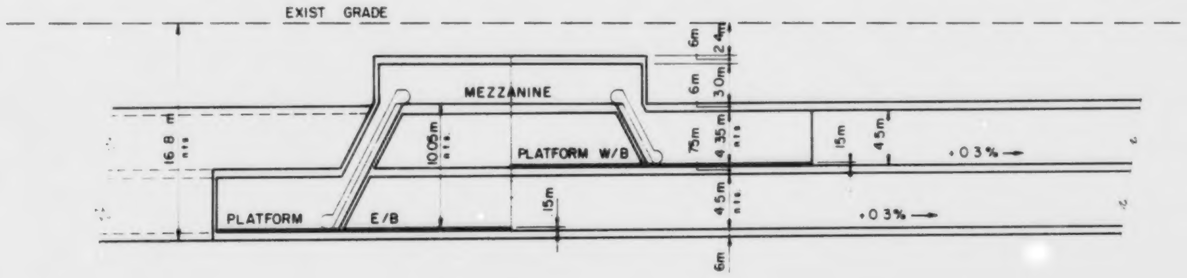
**EXHIBIT 6.7**


QUEEN OR ALBERT ST
S/L
A
5 REGULAR BUSES
3 ARTICULATED BUSES
B
18.0m ROW
n.t.s
S/L
35m DECELERATION TAPER
50m ACCELERATION TAPER
50m MEZZANINE
110 m PLATFORM
15.1m
BUSWAY
B
A

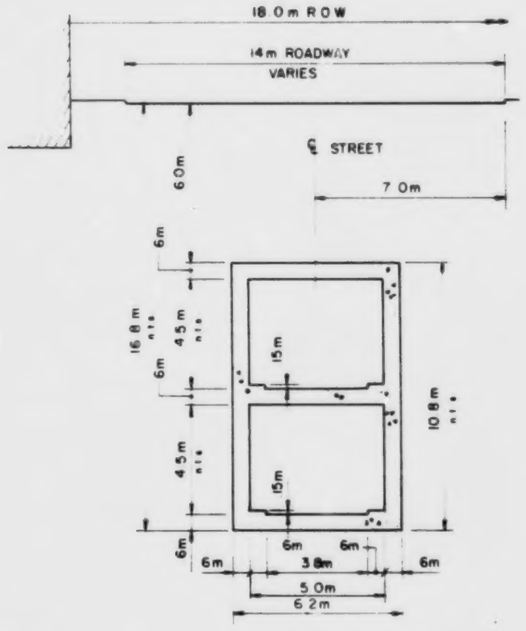
PLAN


℄ STREET
18.0m ROW
2.4m MIN
15.1m
3.6m
.6m
3.0m
.6m
4.5m
4.2m
7.3m
14.4m
10.8m
.6m
4.5m
5.0m
RUNNING TUNNEL
.6m
1.8m
.6
1.8m
.6m
7.3m
4.2m
.6m
2.4m
12.7m

SECTION A-A


EXIST GRADE
.6m
2.4m
.6m
3.0m
MEZZANINE
16.8m
n.t.s
10.05m
n.t.s
PLATFORM W/B
7.5m
4.35m
n.t.s
1.5m
4.5m
+0.3%
PLATFORM
E/B
1.5m
4.5m
n.t.s
+0.3%
.6m

PROFILE


18.0m ROW
14m ROADWAY
VARIES
℄ STREET
6.0m
7.0m
.6m
16.8m
n.t.s
4.5m
n.t.s
1.5m
.6m
4.5m
n.t.s
1.5m
10.8m
n.t.s
.6m
.6m
.6m
.6m
3.8m
.6m
5.0m
6.2m

SECTION B-B

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / T.T.C.L.

**CUT AND COVER OPTION**
**TYPICAL STATION LAYOUT**
**FOR OVER UNDER CONCEPT**

platform at each level and a 50 metre long mezzanine above. Platforms are 110 metres long and 4.2 metres wide except at stairs and escalators where the platform width is 1.8 metres. Again, to provide a consistent minimum platform width of 4.2 metres additional property would be required to accommodate one stair and one escalator to both platforms. As an alternative, stairs and escalators could be located at the end of the platforms.

Summary of the features of 'over and under' alternatives:

- Platform width is 4.2 metres except at stairs and escalators where it is 1.8 metres. Additional property is required to achieve wider platforms.
- Two bus lanes are provided: a loading lane and a passing lane at each platform.
- To maintain a consistent minimum 4.2 metre platform, additional property (sub-surface easement) is required to provide one stair and one escalator from the mezzanine to each platform. If the passing lane is eliminated, the width of additional property required for stairs or escalators is greatly reduced, however some additional property will still be required.

## 6.4 Construction Techniques

### 6.4.1 General Description

Use of the 'cut-and-cover' method of construction can result in disruption to roadway traffic or it could involve the complete closing of roadways while excavation, construction and street restoration are underway. The choice of whether to close the street or maintain street traffic by using the decking technique is based on:

- the need to minimize disruption by maintaining street traffic; and
- the additional cost of street decking.

As a further example of these principles, at the time of writing this report, there are two major transit construction projects underway in Toronto:

- the Harbourfront LRT line; and
- Bloor/Yonge Station enlargement.

In the first case, the Harbourfront LRT line, the decision was made to close Bay Street to regular traffic from Front to Queen's Quay to reduce construction costs and facilitate construction. Minimal decking is provided to maintain pedestrian traffic and vehicle access to adjacent buildings and properties.

In the second case, Bloor/Yonge Station, decking is used to maintain four lanes of traffic and two sidewalks at all times during rush hours with two lanes of traffic maintained in non-rush hour periods and during two 3-week periods when decking is installed and removed.

In Seattle, the Pine Street portion of the underground transit facility was constructed using cut-and-cover construction techniques. They left the street closed to traffic except through holiday shopping period when it was decked. Pedestrians had access at all times.

For the RMOC Central Area Transitway, it has been assumed that it is necessary to maintain street traffic on all east-west and north-south streets during construction. Further, the additional costs of decking are necessary to minimize traffic disruption during construction and to maintain pedestrian and delivery access to the adjacent buildings.

The following description of 'cut-and-cover' construction technique summarizes how construction can be achieved for the four alternatives being considered while maintaining vehicle and pedestrian traffic with minimal disruption in the Ottawa Central Area. The technique uses decking to maintain:

- sidewalks on both sides of the street at all times;
- a minimum of two lanes of traffic (one in each direction on two-way streets and two lanes of traffic in one direction on one-way streets)

during non-rush hour periods and while the deck is being installed or removed;

- a minimum of three lanes of traffic during rush hours;
- uninterrupted access to all driveways and property entrances for passage of vehicles and pedestrians.

In the 'cut-and-cover' method of construction, the roadway is excavated in one-half block sections to a depth of approximately five metres. A temporary wooden deck is placed over the excavation and normal street traffic is resumed. Further excavation and construction are then carried out under the decking.

The decking would be installed on one-half of the street at a time utilizing a temporary support in the centre of the street. When the second half is installed, the support girders would be joined and the temporary supports removed to provide a clear span for the completion of excavation and construction. Decking at intersections would be carried out on weekends, or at night, to minimize traffic disruption. In non-rush hours, the Contractor would utilize one or two lanes for the work that has to be carried out from the surface. Access ramps to under the deck would be located at the ends of the construction area or at right angles on side streets.

The 'split' alternative, where eastbound bus traffic is under one street and westbound is under another, would simplify building access and traffic problems since a portion of the street would not be affected except at stations and at areas where utilities or other factors intervene.

Previous figures show the typical cross-sections for each of the four options and illustrate the procedure necessary for the shoring, earth excavation, rock excavation and deck support. The space required for shoring and rock excavation reduces the maximum width of structure that can be constructed on the narrow streets.

### 6.4.2 Construction Procedure

The several steps in the 'cut-and-cover' method of construction are as described in the following:

> The first operation is to dig a trench on each side of the street along the outside lines of the excavation for the Transitway structure. The trenches are taken down to rock level which averages about five metres below the roadway surface. These trenches locate the various utilities and their feeders to buildings so that services can be maintained during construction. As the trench is excavated, a concrete wall about 0.6 metres thick is placed in it. This wall extends from the roadway to approximately 0.6 metres into the solid rock below. The walls provide support for the sides of the excavation and for the temporary street decking. They also ensure that support for adjoining building foundations is maintained.
>
> In some cases, when the line of the excavation is a sufficient distance from the adjacent buildings, or where the buildings are set back from the street line, it may be more appropriate to install steel piles in the trench rather than a concrete wall. The piles would be anchored in the rock below and wooden sheeting would be installed between the piles to support the sides of the excavation. The piles would also act as support for the deck beams.
>
> Excavation of the street between the walls now proceeds. When the excavation reaches a sufficient depth, steel trusses or girder beams spanning the excavation are placed about every four metres resting on the concrete walls. The trusses are used at stations where the span is too wide for girder beams. The trusses or girder beams carry the street decking timbers. The pipes and conduits of the utilities are suspended from the trusses or beams.

Excavation continues with crews working either through the deck or underneath it. Shovels can work through openings made by the removal of timbers and the earth can be loaded on trucks at the surface. In other cases, the excavation can be carried out below the deck and the earth can be loaded on trucks and carried up ramps to the surface for disposal.

When all of the soft earth has been removed, holes are drilled in the rock underneath it to the final depth of the excavation. These holes are charged and a blast mat is placed over the rock. Blasting is then carried out to break up the rock and allow its removal by shovel or clam.

Removal of the loosened rock can be either through the deck or up ramps to the surface. In order to ensure that the concrete cut-off walls are securely anchored in rock, the neat line of rock excavation is located 0.6 metres from the face of the wall. Additional temporary bracing is installed across the cut where it is required. Rock bolts are installed in the concrete walls to anchor them to the rock.

When the excavation has been complete, the next step is to place the reinforced concrete invert of the structure. Once the invert is in place, the walls are formed and the concrete is placed for them. Finally, the roof and any other structures required are completed. Placing of the mass concrete for the structures is accomplished by creating openings in the deck by the removal of timbers and working through these openings.

After the Transitway structure is completed, the open area above is filled with sand and the utilities are restored to their permanent locations. The temporary decking is removed and the street is repaved ready for pedestrians and vehicular traffic.

The decking operation would be carried out on a progressive basis, one-half block at a time, and on two headings (work locations) at least two blocks apart. The estimated time to install the decking, excluding the installation of shoring walls or piles which would be installed in advance, is two to three weeks for each one-half block section. The estimated time to remove the deck and repave the street would be somewhat less than the time required for decking; however, the decking would be removed incrementally as the structure is completed. A more detailed description of the construction schedule and sequence follows.

### 6.4.3 Construction Sequencing and Schedule

The duration of typical 'cut-and-cover' construction and the sequence in which it is performed varies from work site to work site and the restrictions that are to be placed on the contractor such as:

- the number of work locations that can be used at any one time;
- the number of access ramps and location of these ramps for the removal of excavation materials and the delivery of new construction materials;
- the number of individual construction contracts and contractors that will be used to construct the total Transitway project.

The following description of construction operations and elapsed times for each operation would apply to the construction of any of the four alternatives. The elapsed times indicated for each of the six basic construction phases can be used to determine the total project schedule for any one of the four alternatives when the number of work locations, contracts/contractors and access/egress points are determined.

The following describes the six basic steps for construction of a 'cut-and-cover' Transitway beginning with preconstruction activities and ending with restoration of the street.

## Preconstruction

Note: - From an overall utility analysis, determine the services that will be maintained in place during construction and choose those that will be rebuilt or relocated.

Operation: - Rebuild or relocate services - by separate contract or by utility authority.

Disruption: - Relocation could be on the same street or an adjacent one (North - South or East - West). Construction would be one lane, one block or one-half a block at a time.

Time: - Time required would vary depending on the number of work locations allowed at one time (controlled by specification) but would generally be approximately two months per block.

Remarks: - The gas company may require upgrading of their lines in order that the General Contractor can support this service during construction (replacement of cast iron with steel mains). If gas lines are in good order, the gas company may work with or supervise work of the General Contractor during construction.

## Preparatory Construction

Note: - This work is generally done just ahead of initial excavation but could be done well in advance with streets and sidewalks restored to normal use.

Operation: - Trench excavation, location of utilities and installation of piles for shoring or concrete cut-off wall for shoring and deck support.

Disruption: - The number and extent of work locations would be established in the specifications as determined by the traffic and transit and building requirements. Two work locations, limited to one-half of a block and one lane at a time are recommended in the downtown area. Pedestrian and car access to buildings would be maintained at all times or other arrangements made by the General Contractor in agreement with the building owners. Most building access points are wide enough to allow maintaining one-half of the access while the other is disrupted. At least two lanes of traffic would be maintained at all times, with three lanes of traffic in rush hours.

Time: - Approximately two weeks per one-half block location.

Remarks: - Work would normally be immediately ahead of the initial excavation but some separation could be specified to reduce the disruption in each block.

## Initial Excavation and Decking

Note: - Construction would be carried out on one-half of a street at a time with traffic being maintained on the other half.

Operation: - Initial excavation to a depth of approximately 4 metres, uncover and prepare utilities for support, install deck support system, support utilities, install deck and restore street to public use.

Disruption: - One-half of a block at a time with temporary access to buildings being moved as required to allow construction to pass building access points.

Time: - Approximately two to three weeks per one-half block work location.

Remarks: - Contractor would be required to work within the one-half street work site with all of his delivery and installation work being carried out from the end of the construction area. Deck beams and decking timber would be installed progressively with cranes and trucks operating on the deck as it is installed.

## General Excavation

Note: - Availability of access/egress ramp locations to remove excavated material from under the deck would have a major effect on the impact of this stage. Approved haul routes and dump site locations would also determine acceptable ramp locations. Ramps could be located through the deck on one lane of the Transitway street, on the north-south streets adjacent by the deck or out of the downtown area in the vicinities of Booth Street in the west, adjacent to the canal and/or the transitway in the east.

Operation: - Excavation of remaining soil and rock to invert of the transitway facility.

Disruption: - Minimal if suitable ramp locations are possible.

Time: - Approximately six months assuming three contractors are working simultaneously at their separate contract locations.

Remarks: - This work would normally be overlapped with the construction of the structure, but this and the total time involved would vary depending on the number and location of the access ramps.

### Installation of Structure

Note: - Most of the material delivery and concrete pouring could be carried out under the deck but allowing the contractor to occupy one lane and work through the deck would improve efficiency and reduce construction cost.

Operation: - Construction of transitway, stations and service structures.

Disruption: - One lane at a time restricted by specification to non-rush hours. Extent of disruption could be kept to a minimum by limiting work through the deck.

Time: - Approximately ten months depending on the overlap possible with the excavation phase and assuming simultaneous construction by three contractors at their locations.

Remarks: - Off-street construction for entrances or structures that come to the surface such as vent and fan shafts would cause varying amounts of disruption depending on site availability.

### Restoration of Street

Note: - The majority of the backfill could be carried out through the deck occupying one lane in non-rush hours.

Operation: - Remove deck, restore utilities, complete backfill and pave street.

Disruption: - Work would be carried out one-half block at a time on one-half of the street with access to buildings being maintained at all times. The number and location of work sites would be similar to those decided on for the installation of the deck. At least two lanes of traffic would be maintained at all times.

Time: - Two to three weeks per one-half block work location.

Remarks: - Surface facilities such as street lights, utility poles, signs and any building restoration could be carried out with the street restoration or as a separate overall contract at a later date.

### Surface Access and Off-Street Structures

Systems such as ventilation and station finishes would be separate contracts following the general construction and would be carried out without surface access other than the installation within buildings and in the vent and fan shaft structures.

The project would be broken up into a number of structural contracts which could run concurrently. Cooperation between contractors on adjacent contracts would be a key issue to control by specification. The downtown section between Bronson Avenue and Elgin Street should be in one contract if ramp access is limited to both ends of this section.

### 6.4.4 Typical Construction Schedule - Split Alternative

The following typical construction schedule has been developed for the split alternative as being representative of the type of construction schedule that may be encountered. To develop this schedule, the following assumptions are made:

1. The split alternative will be constructed using three separate construction contracts and contractors dividing the work as follows:
   - Contract A will extend from the west portal at Booth Street through to Kent Street;
   - Contract B will extend from Kent Street to immediately east of the Canal (Contract B includes the construction of the structure underneath the Canal);
   - Contract C will extend from east of the Canal through to the Campus Station/Waller Street portal.

2. Access for construction purposes, that is removal of excavation material and delivery of new construction materials, will be provided as follows:

   - for Contract A, access would be provided at the west portal and via a ramp occupying one lane of traffic on Kent Street for both the Queen Street and Albert Street structures (these ramps on Kent Street would be shared with Contractor B);

   - for Contract B, access would be provided via the shared construction ramps occupying one lane on Kent Street and at the east end of Contract B a construction access ramp immediately east of the Canal with access to Colonel By Drive. The access ramp to Colonel By Drive would be shared with Contractor C;

   - for Contract C, access would be provided via the shared access ramp at Colonel By Drive and access would also be provided at the east portal on Waller Street.

3. All three contracts A, B and C, would be required to maintain pedestrian and vehicle access on all roadways as follows:

   - maintain pedestrian sidewalks on both sides of the street at all times;

   - during non-rush hour periods and while decking is being installed (Phase III) maintain a minimum of two lanes of street traffic at all times;

   - during rush hour operations except during decking installation maintain a minimum of three lanes of street traffic at all times;

   - maintain access to all driveways and property entrances for free passage of vehicles and pedestrians at all times.

4. All three contracts, Contracts A, B and C, would be awarded at approximately the same time so that construction activities would be carried out for the three contracts generally simultaneously.

5. The Canal will be drained for approximately six weeks during construction of the transitway under the Canal (Contract B).

To determine a total schedule for construction of the entire project from the west portal through to the east portal, a schedule was developed for Contract B, which because of its length and location, would likely be the most time consuming to complete. This representative (order of magnitude) construction schedule is as follows:

| Operation | Time Period (Weeks from Notice to Proceed) | Remarks |
|---|---|---|
| 1. Preconstruction - rebuild or relocate utilities services (by separate contract or by Utility Company). | Week 1 to Week 13 | Assumes relocation of one major utility such as sewers. |
| 2. Preparatory Construction - trench excavation, location of utilities and installation of piles for shoring or concrete cut-off wall for shoring and decking support. | Week 7 to Week 20 | Assumes two one-half block work locations on both Queen Street and Albert Streets. |
| 3. Initial Excavation and Decking - initial excavation to a depth of approximately four metres, uncover and prepare utilities for support, install deck support system, support utilities, install deck and restore street to public use (with decking). | Week 10 to Week 29 | Assumes two one-half block work locations on both Queen Street and Albert Streets. |
| 4. General Excavation - excavation of remaining soil and rock to invert of the transit facility | Week 15 to Week 40 | Work will proceed at two locations on both Queen Street and Albert Street with access ramps through the deck. |
| 5. Installation of Structure - construction of transitway, stations and service structures. | Week 20 to Week 63 | Work will proceed at two locations on both Queen Street and Albert Street with concrete and other materials delivered through the deck. |
| 6. Restoration of Street - remove deck, restore utilities, complete backfill and pave street. | Week 30 to Week 73 | Work will follow incrementally as the structure is completed at two locations on both Queen Street and Albert Streets. |

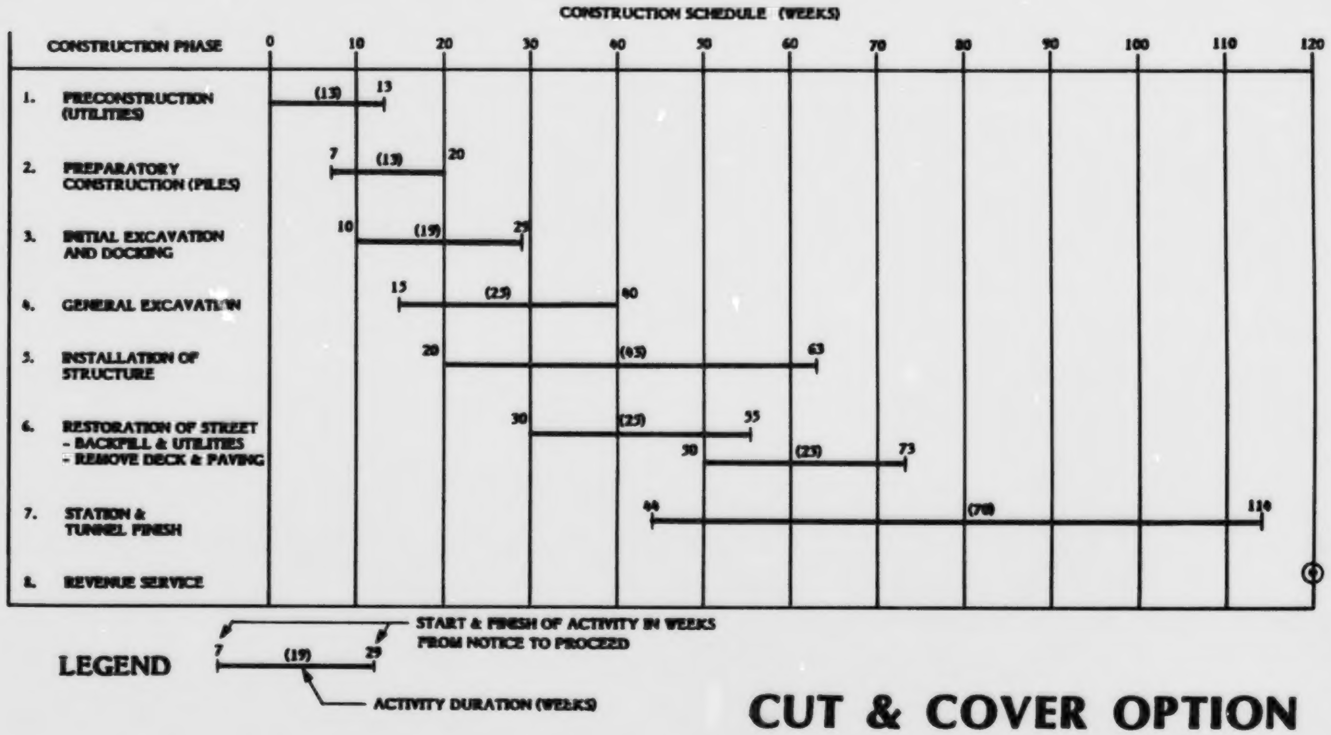
Based on the above, the elapsed time to build the transitway structures (general construction) for Contract B would be approximately 73 weeks (1½ years). Station finish contracts and installation of mechanical and electrical equipment throughout the stations and structures would follow the completion of the general construction phase. These contracts could be broken into similar geographic areas to the general construction contractors (Contracts A, B and C) or they could be separated into smaller packages dealing with stations and the adjacent running structures. In any event, the duration of the station finish and mechanical and electrical contracts would be approximately 70 weeks after completion of the general construction; however, station finish contracts could commence as portions of the structure are completed at approximately 44 weeks after start of construction. This station finish contracts would be completed at week 114.

Station finish and mechanical and electrical contracts can be scheduled so that the work at busway level is completed first, leaving the mezzanines and station entrance areas for final completion just before start of revenue service. In this manner, OC Transpo can be provided access to the transitway level for training, testing and commissioning purposes during the last two to three months of the total construction project when mezzanine and street entrance level stations finish contracts are being completed.

Based on the above consideration, Contract Area B of the RMOC Transitway can be constructed and completed within approximately 114 weeks (2½ years) from notice to proceed and beginning of construction. Assuming that Contracts A and C are performed in sequence, then the total project can also be completed within this time frame. **Exhibit 6.8** illustrates the duration of the basic Construction stage, the amount of overlap and the overall duration. This is an optimisitc estimate that assumes no unforeseen events and also no problems with utility or traffic. A more conservative estimate, after discussions with the major utility agencies would see the construction period closer to 3 to 3½ years.

## EXHIBIT 6.8

**RMOC - CENTRAL AREA TRANSITWAY**
**CUT-AND-COVER OPTION**



## CUT & COVER OPTION TYPICAL CONSTRUCTION SCHEDULE

### 6.5 Comparison of the Four Cut-Cover Alternatives

The four cut-cover alternatives were reviewed and compared to each other to identify a preferred option. Among the factors considered were:

- Station Entry: Property Acquisition and Compensation

  It is anticipated that entrances will have to be located in some of the major buildings or on private property requiring extensive negotiation. This requirement is the same for all alternatives.

- Ventilation Structure and Equipment

  Ventilation requirements are subject to a decision on the fuel to be used in this system. All four would require the same solutions. The primary sizing of the facility would be determined by fire requirements.

- Signals and Control Systems

  Apart from passenger information, control and security, signals and control systems are not generally required for bus operation unless a guideway system is used. This factor would not affect the relative ranking of the options.

- Utilities

  Utilities would be a major cost item since it would be necessary to relocate the storm and sanitary sewers to adjacent streets and construct new shortrun collector sewers on both sides of the Transitway structure to serve the buildings on that street. These collectors would be connected to the sewers on the adjacent street at each block to keep the size to a minimum. It may also be possible to make some connections in the cross streets if capacity is available.

  The utilities on both the east-west and north-south streets, other than sewers, are relatively flexible and can be supported during construction and restored in the backfill above the structure.

  The utilities on both of the east-west streets being considered are roughly the same and the support, restoration, relocation and rebuilding would be roughly equivalent for the four options. The one exception is the Bell Utilities on Albert Street in front of the major switching Terminal Building. The utilities on Albert Street in front of this building are very extensive and their relocation may require extended construction periods. In the worst case, this section of Albert may have to be closed to all through traffic for a three to six month period, with the expected major problems for OC Transpo and other street traffic.

  Sewers on the north-south streets may have an impact on construction costs. The depth of the structure can be varied, at an increased cost to avoid the need to relocate or siphon north-south sewers that conflict with the structure when it is located at minimum depth. In order to evaluate the cost effectiveness of lowering the structure, a complete evaluation must be made of the entire network of storm and sanitary sewers to determine the least expensive sewer relocation/reconstruction design that can be developed to avoid the conflict with the higher structure (minimum 2.4 metre cover). The cost of this sewer reconstruction can then be compared with the increased costs of the lower structure. As an alternative to lowering the structure or major sewer relocation, siphons on the smaller diameter north-south sewers may be practical.

- Off-Street Property Required for Platforms or Mezzanine to Platform Access

  As identified previously, all options considered, except the 'split' option, will require some sub-surface property or easements if the minimum platform width of 4.2 metres is to be achieved and for mezzanine to platform stairs and escalators.

As these property requirements do not include any surface area (they are all sub-surface easements) and are typically below the level of adjacent building footings and basements, their cost should be relatively low. However, they do represent a real cost that can only be developed when a detailed station design is produced for each location taking into account the location, depth and design/usage of the specific buildings impacted.

Thus, in comparing the options, the 'split' option is the only option where extensive additional costs for sub-surface easements are not required. Also, if the Transitway structure extended beneath adjacent buildings, extensive underpinning would be required and this would represent a significant cost item.

- Platform Widths

  Problems in achieving the desirable minimum width of 4.2 m was experienced in all but the split option. Platform widths could be achieved at the expense of increased property requirements and underpinning requirements for adjacent buildings.

- Street Disruption

  All options involve a significant amount of street disruption. The options which use one street concentrate the impacts on that street whereas the split option lessens the impact on each street but affects two streets. One of the requirements would be to maintain access and a minimum number of lanes open at all times.

- Transit Routing

  Significant impact on buses can be expected on all options except where Queen Street is selected in which case the impact would be less than on Albert or Slater. With the split option, it is anticipated that severe problems would occur during extended periods of time when decking is being installed and removed.

- Passenger Access

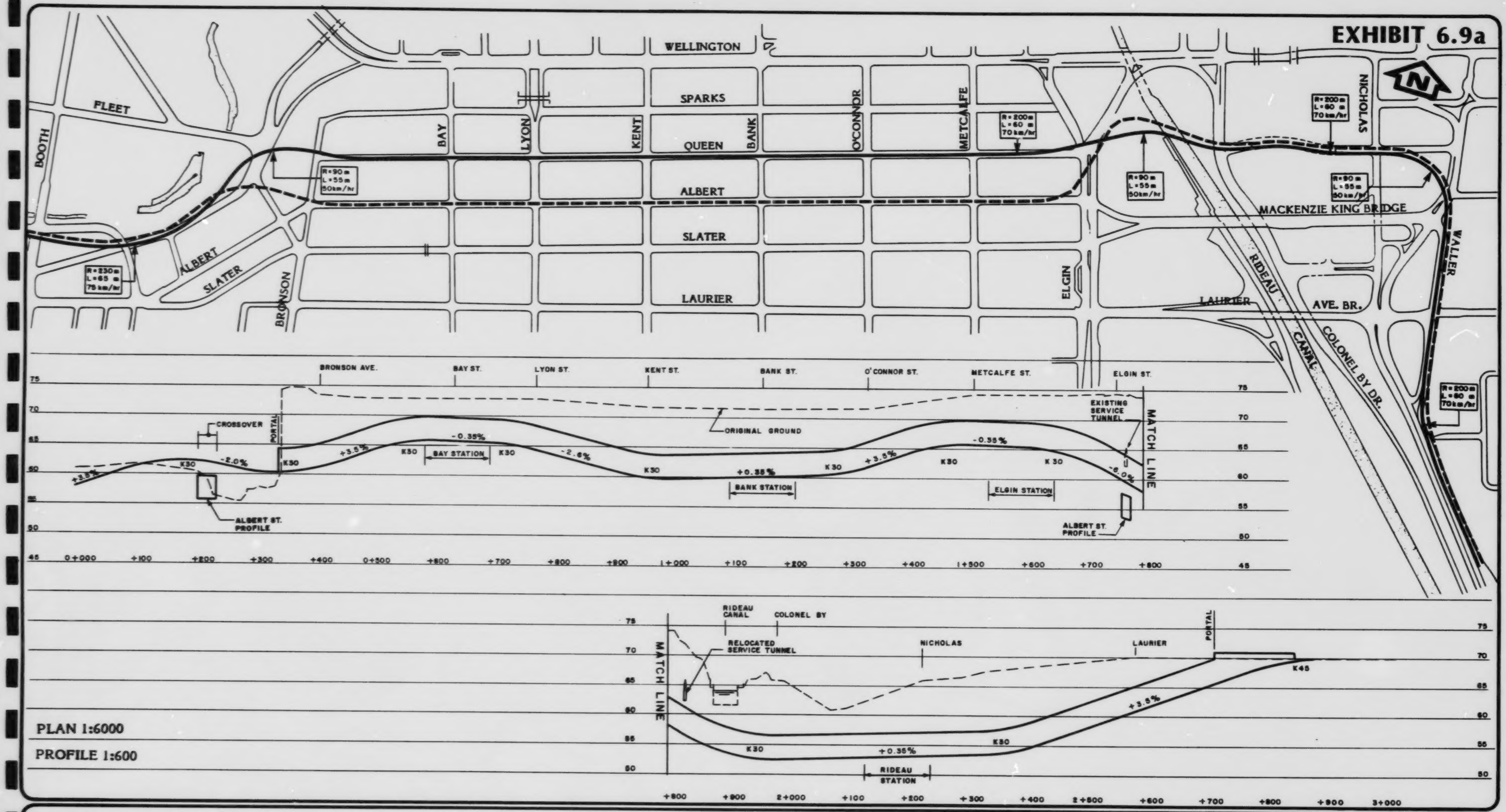
  The options can all provide the required level of access. When the station platforms are closest to the surface vertical transportation requirements will be minimized. To provide for full passenger control, it will be necessary for all options to use mezzanines and this will mean that the platform elevations are not significantly different between the schemes.

After comparison of the four alternatives, the split alternative is recommended. See **Exhibit 6.9a,** Queen Street plan, and 6.9b, Albert Street plan.

Construction disturbance to a street is less than in the other schemes allowing almost continuous traffic on the 'off' side except at stations. Interruptions of vehicle access to buildings is the least of all of the alternatives. It has the disadvantage of disruption on two streets.

The disturbance factors are not greatly different in all alternatives. It is in the area of passenger movement and convenience that the split alternative enjoys a distinct advantage with its shallow depth and adequate width platforms. The most important factor to consider is operating efficiency because construction is over in a relatively short period of time; however, the efficient operation and convenience to passengers has a very long-term impact.

**EXHIBIT 6.9a**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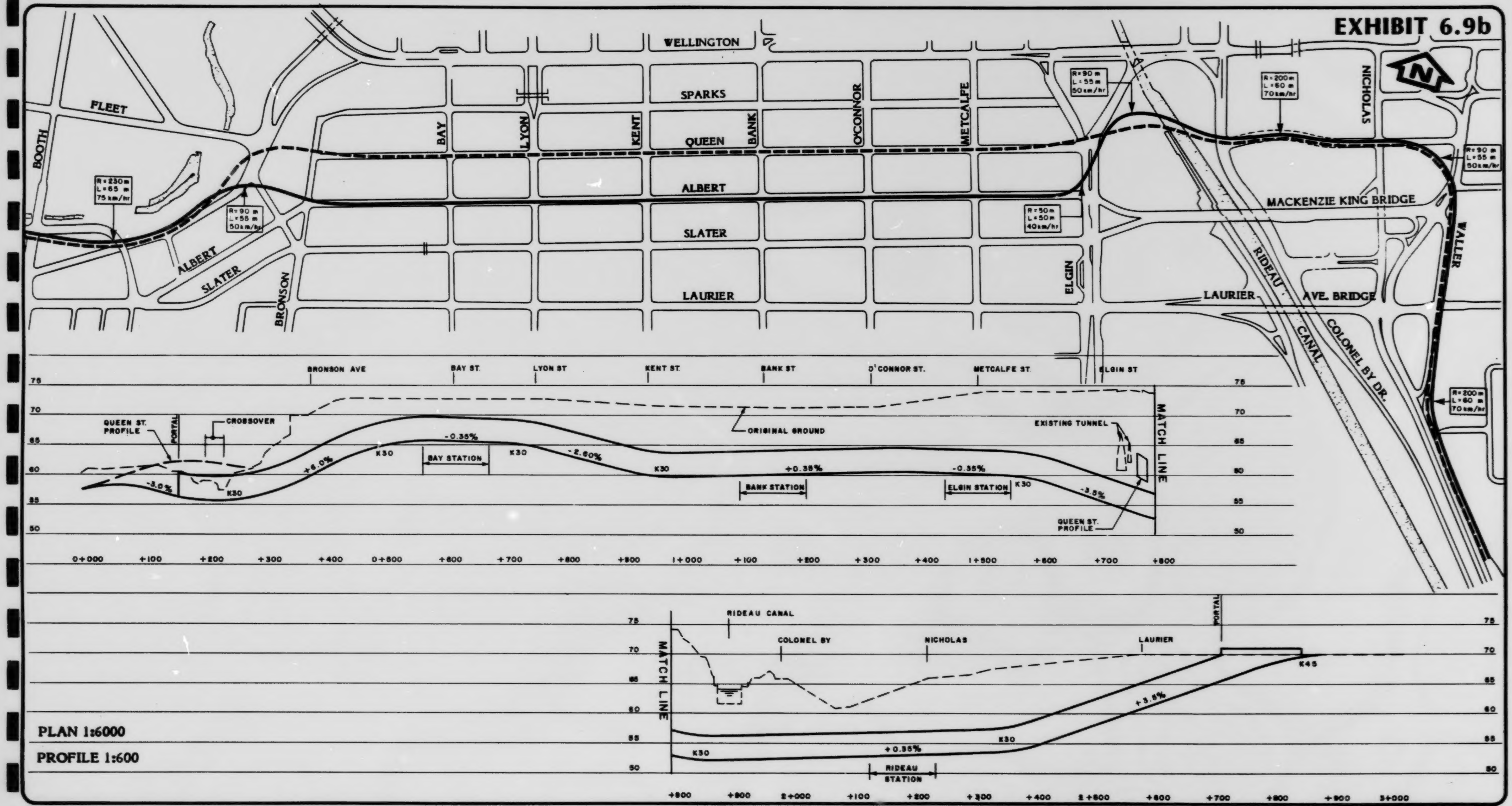
REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN /T.T.C.L.

CUT AND COVER OPTION
SPLIT CONCEPT
PLAN AND PROFILE
QUEEN STREET

**EXHIBIT 6.9b**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**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** /T.T.C.L.

**CUT AND COVER OPTION**
**SPLIT CONCEPT**
**PLAN AND PROFILE**
**ALBERT STREET**

## 6.6 Summary and Conclusions

### 6.6.1 Summary

- Of the four alternative cut-and-cover schemes, the split alternative was selected as the preferred one. The split alternative features a twin Transitway with eastbound travel under Queen Street and westbound travel under Albert Street.
- The Transitway structures would be crossed over at the west end before entering the escarpment, and would cross back just north of the NAC. There would be two lanes through each station area, thus permitting a passing lane.
- The three stations in the Central Area west of Elgin Street would feature a connection between the east and westbound Transitway structures. The station at the Rideau Centre would be a side platform station with access into the Rideau Centre. Platform widths of 4.2 metres can be provided. A wider platform, 6.0 m., would be possible but only with intrusion onto private property.
- The split option would require substantial street level disturbance during the construction period, especially during the utility relocation phase, and the installation and removal of the deck structure.
- Pedestrian access to businesses along Albert and Slater streets can be maintained at all times.
- Vehicular access to buildings can will be maintained although the street capacity will be substantially reduced at times. It is anticipated that 2 lanes could be maintained at all times. Surface bus operations will be severely affected with rerouting of some routes a requirement. Service will require extra time to traverse the construction area.
- Utility relocation will provide a significant challenge, especially in front of the Albert Street Bell Telephone Building. It may be that this very extensive and sensitive telephone duct relocation will require that Albert Street be closed off to through traffic for possibly up to 6 months.
- This construction period will be at least 2½ years, but more likely 3 to 3½ years due to utility and traffic.
- After construction, the street can be restored to full use and streetscape opportunities explored.
- Exhaust ventilation structures will be required, and can be appropriately located along the right-of-way.
- To underpass large utilities on Bank Street and Kent Street, the Transitway will have to be located at a lower elevation. In addition, to avoid the Place de Ville underground passage way across Queen Street, the profile will have to be at least 17 m below the surface, not significantly different from the tunnel profile.
- Grades, curvatures and vehicle clearance envelopes are compatible with rail transit.

### 6.6.2 Conclusions

The detailed analysis completed in this study identified the "split" option as the preferred cut-and-cover option. This option uses Queen Street and Albert Street right-of-way between Bronson and Elgin. East of Elgin Street the two running structures are brought together to pass north of the NAC and into the Daly Avenue corridor. In addition to the cost of construction, there are significant other costs that must be recognized in the final decision. These costs include:

- business and commercial impacts during construction;
- impacts on the transit service during construction; and
- impacts on other street traffic during construction.

# CHAPTER 7

# 7.0 TUNNEL OPTION

## 7.1 Introduction

This section presents the results of the technical analysis and concept design investigation of the tunnel option. During Phase I of the study, three main tunnel alignments, each with combinations of two single-lane tunnels beneath two adjacent streets or one double-lane tunnel beneath one street, were investigated - 10 alignments in all. During the Phase II study, the alignment running parallel to the canal ran through an area of adverse geology and was dropped. The two other alignments and their variations were further studied and developed. The various tunnel schemes studied are summarized **on Exhibit 7.1.**

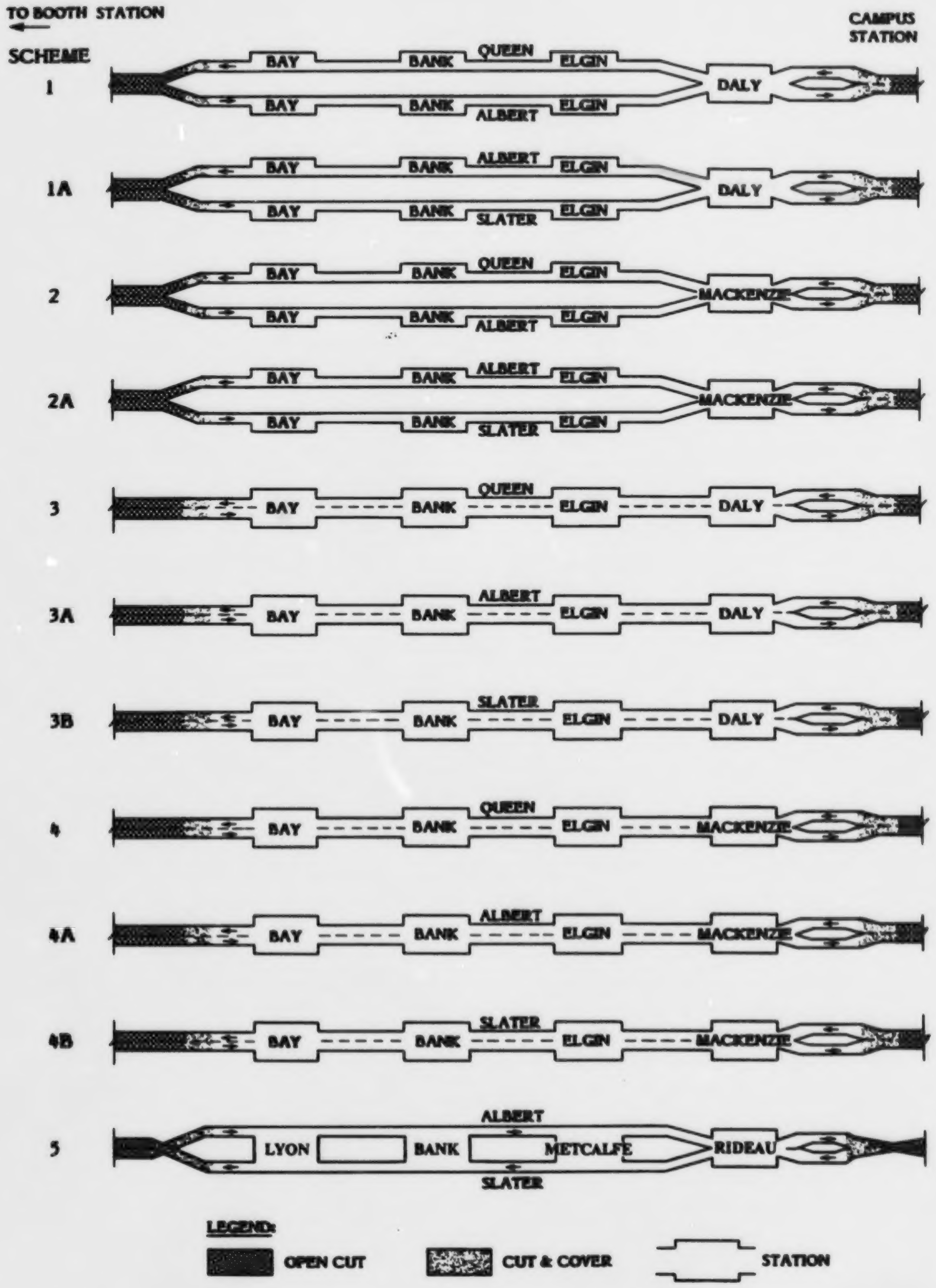
The tunnel schemes were compared on the basis of construction costs, scheduling, environmental impact, disturbance to traffic and potential for future expansion. Conclusions and recommendations regarding selection of the preferred tunnel scheme are summarized at the end of this chapter.

Tunnel alignments and locations of portals for various schemes are presented in Section 7.2. Tunnel and station geometrics and sizes are discussed in Section 7.3. Typical support systems for the tunnel, station, mezzanine and connecting pedestrian tunnel are included in Section 7.4. Ventilation and safety considerations are discussed in Section 7.5. The construction schedules for various tunnel schemes studied are included in Section 7.6. General discussions on comparison of various tunnel schemes have been outlined in Section 7.7.

## 7.2 Tunnel Alignments and Associated Portals

Optimum tunnel alignments and portal locations were selected following evaluation of the topography and knowledge of the geologic conditions. Optimization of the tunnel alignment was carried out to achieve maximum economy, construction ease, and limited disturbance to the traffic or the

**EXHIBIT 7.1**



**TUNNEL OPTION**
**VARIOUS ALTERNATIVES STUDIED**

public at the street level. The various tunnel schemes studied are summarized on **Exhibit 7.1.**

### 7.2.1 Twin Tunnel Schemes

#### 7.2.1.1 Alignments for Schemes 1 and 1A

The proposed alignments for Schemes 1 and 1A (twin single-lane tunnel schemes) leave the Campus Station and follow the existing Transitway using open-cut and cut-and-cover methods **(Exhibit 7.2 and 7.3).** Once an adequate cover of 5 m above the crown is reached, two single-lane tunnels separated by a central pillar of 3.0 m width would start. Initially the tunnels would be driven in soil for a short distance followed by tunnelling in rock. The rock tunnels would extend beneath Waller Street and then turn into Daly Avenue where the Rideau Centre Station would be located. The station would be constructed underground with limited disruption to the traffic on Daly Avenue and Nicholas Street.

Beyond the station, the two tunnels would pass beneath the Rideau Canal and the National Arts Centre and head towards: Scheme 1 Queen Street (for (westbound) and Albert Street (eastbound), or alternatively Scheme 1A: Albert Street (westbound) and Slater Street (eastbound). The individual single-lane tunnels would continue beneath the two streets to the escarpment at Bronson Avenue.

Three stations would be located in the downtown area. Access to the stations would be provided either from the existing buildings, street access points, or from off-street sites such as existing parking lots. A pedestrian tunnel would serve as the connection between the east and west bound tunnels and also provide space for fare control activities.

At the western end of the corridor near the base of the escarpment the Transitway would have a short length of cut-and-cover construction and an open-cut section prior to reaching the proposed Lebreton Station at Booth Street.

#### 7.2.1.2 Alignments for Schemes 2 and 2A

The proposed alignments for Schemes 2 and 2A (twin tunnel schemes) near the Campus Station are similar to alignments for Schemes 1 and 1A, except the twin tunnels instead of driving north along Waller Street to Daly Avenue, turn into an alignment under the MacKenzie King Bridge **(Exhibits 7.4 and 7.5).** Due to the lack of an adequate rock cover, the station at the south end of the Rideau Centre would have to be constructed by cut-and-cover method. This would entail replacement of the bridge.

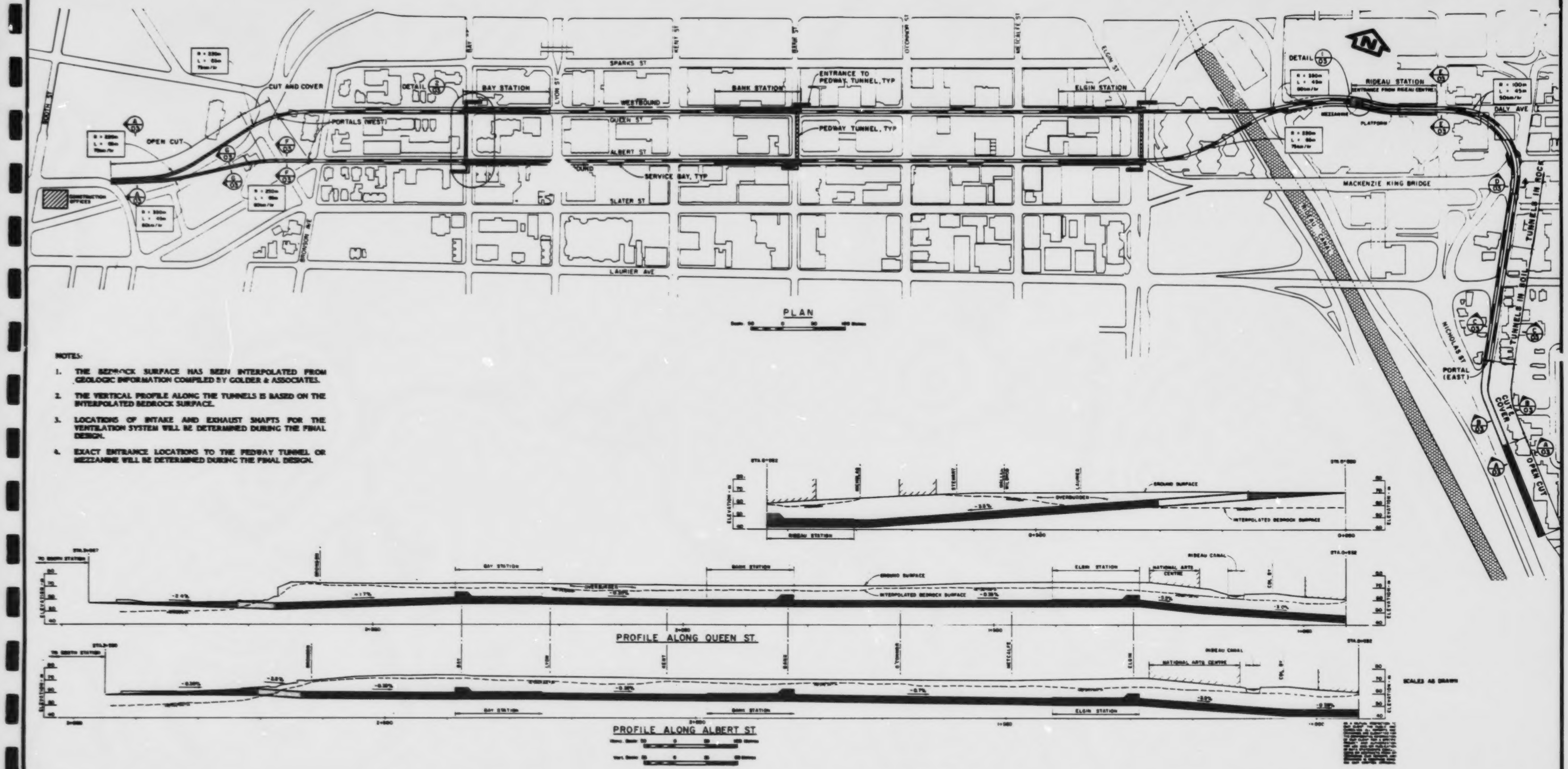
After leaving the station, the twin tunnels would run beneath the bridge and into Queen Street (westbound) and Albert Street (eastbound) for Scheme 2; alternatively Albert Street (westbound) and Slater Street (eastbound), Scheme 2A. The western portion of these alignments would follow those proposed above for Schemes 1 and 1A, respectively.

### 7.2.2 Single Tunnel Schemes

#### 7.2.2.1 Alignments for Schemes 3, 3A and 3B

The proposed alignment between the Campus Station and the Rideau Centre Station for Schemes 3, 3A and 3B are identical to Schemes 1 and 1A. After leaving the Rideau Centre Station, a double-lane tunnel would lead towards and run beneath Queen Street, Scheme 3 **(Exhibit 7.6),** or Albert Street, Scheme 3A **(Exhibit 7.7),** or Slater Street, Scheme 3B **(Exhibit 7.8).** The alignments of the schemes at the western end are similar to the alignments for Schemes 1 and 1A.

**EXHIBIT 7.2**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BAY STATION
BANK STATION
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RIDEAU STATION
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CUT AND COVER
OPEN CUT
PORTALS (WEST)
WESTBOUND
EASTBOUND
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PEDWAY TUNNEL, TYP
SERVICE BAY, TYP
CONSTRUCTION OFFICES
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RIDEAU CANAL
DALY AVE
NICHOLAS ST
MEZZANINE
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SCALES AS DRAWN

NOTES:

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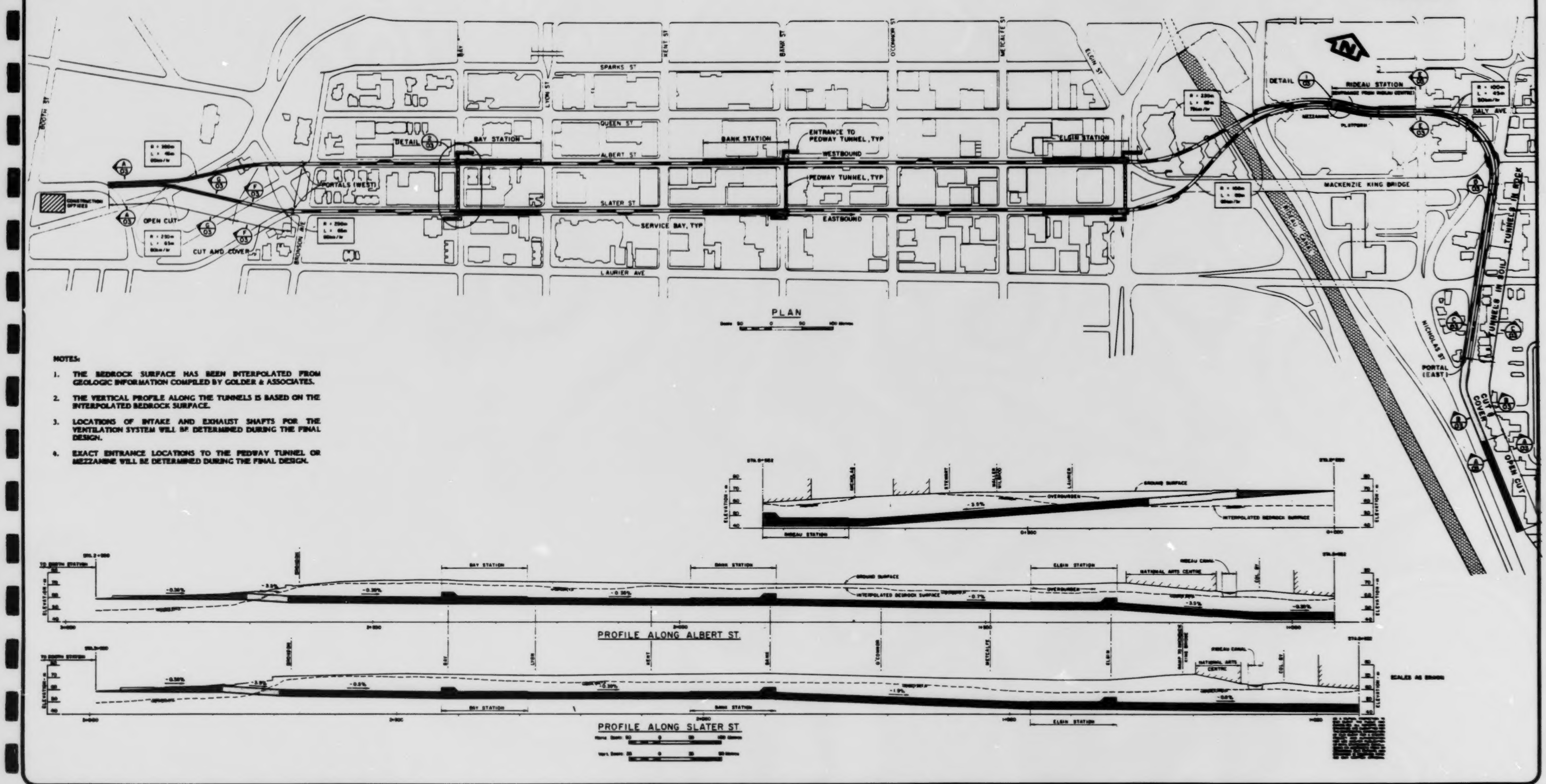
4. EXACT ENTRANCE LOCATIONS TO THE PEDWAY TUNNEL OR MEZZANINE WILL BE DETERMINED DURING THE FINAL DESIGN.

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**SCHEME 1**
**PLAN & PROFILES**

**EXHIBIT 7.3**


BOOTH ST
BAY
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST
ELGIN ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
BRONSON AVE
CONSTRUCTION OFFICES
PORTALS (WEST)
OPEN CUT
CUT AND COVER
DETAIL
BAY STATION
BANK STATION
ENTRANCE TO PEDWAY TUNNEL, TYP
WESTBOUND
PEDWAY TUNNEL, TYP
EASTBOUND
SERVICE BAY, TYP
ELGIN STATION
RIDEAU STATION
MEZZANINE
PLATFORM
DALY AVE
MACKENZIE KING BRIDGE
RIDEAU CANAL
TUNNELS IN ROCK
TUNNELS IN SOIL
NICHOLAS ST
PORTAL (EAST)
CUT COVER
OPEN CUT
N
GROUND SURFACE
OVERBURDEN
INTERPOLATED BEDROCK SURFACE
ELEVATION - m
TO BOOTH STATION
NATIONAL ARTS CENTRE
SCALES AS SHOWN

PLAN

PROFILE ALONG ALBERT ST.

PROFILE ALONG SLATER ST.

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**CENTRAL AREA TRANSITWAY**
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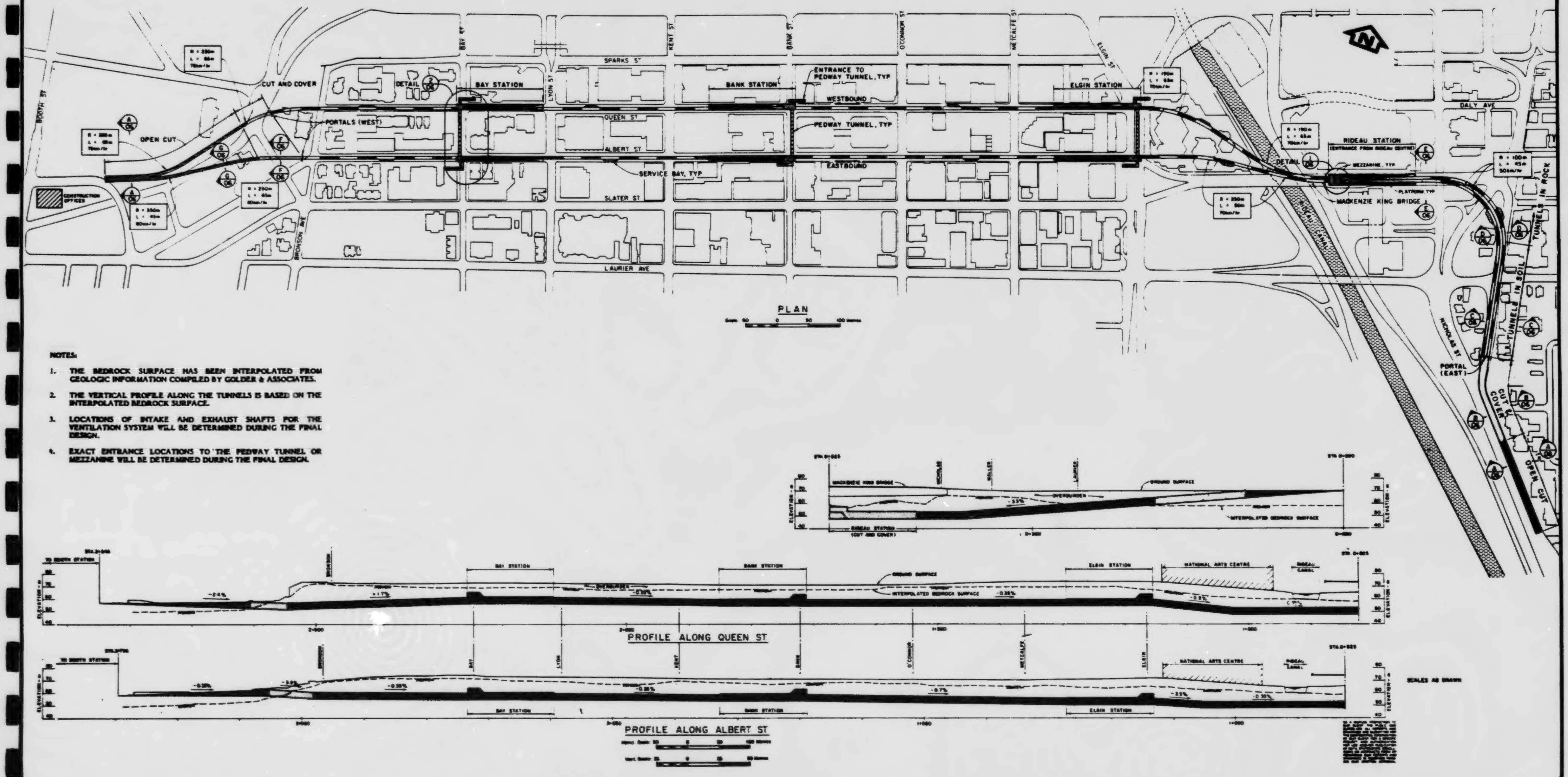
**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**SCHEME 1A**
**PLAN & PROFILES**

## EXHIBIT 7.4


BOOTH ST
OPEN CUT
CUT AND COVER
PORTALS (WEST)
DETAIL
CONSTRUCTION OFFICES
BRONSON AVE
BAY ST
BAY STATION
LYON ST
KENT ST
BANK ST
BANK STATION
O'CONNOR ST
METCALFE ST
ELGIN ST
ELGIN STATION
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
SERVICE BAY, TYP
ENTRANCE TO PEDWAY TUNNEL, TYP
WESTBOUND
PEDWAY TUNNEL, TYP
EASTBOUND
RIDEAU CANAL
RIDEAU STATION
(ENTRANCE FROM RIDEAU CENTRE)
MEZZANINE, TYP
PLATFORM TYP
MACKENZIE KING BRIDGE
DALY AVE
NICHOLAS ST
TUNNELS IN ROCK
TUNNELS IN SOIL
PORTAL (EAST)
CUT & COVER
OPEN CUT
N
PLAN
MACKENZIE KING BRIDGE
GROUND SURFACE
OVERBURDEN
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION (CUT AND COVER)
TO BOOTH STATION
NATIONAL ARTS CENTRE
RIDEAU CANAL
ELEVATION - m
PROFILE ALONG QUEEN ST
PROFILE ALONG ALBERT ST
SCALES AS DRAWN

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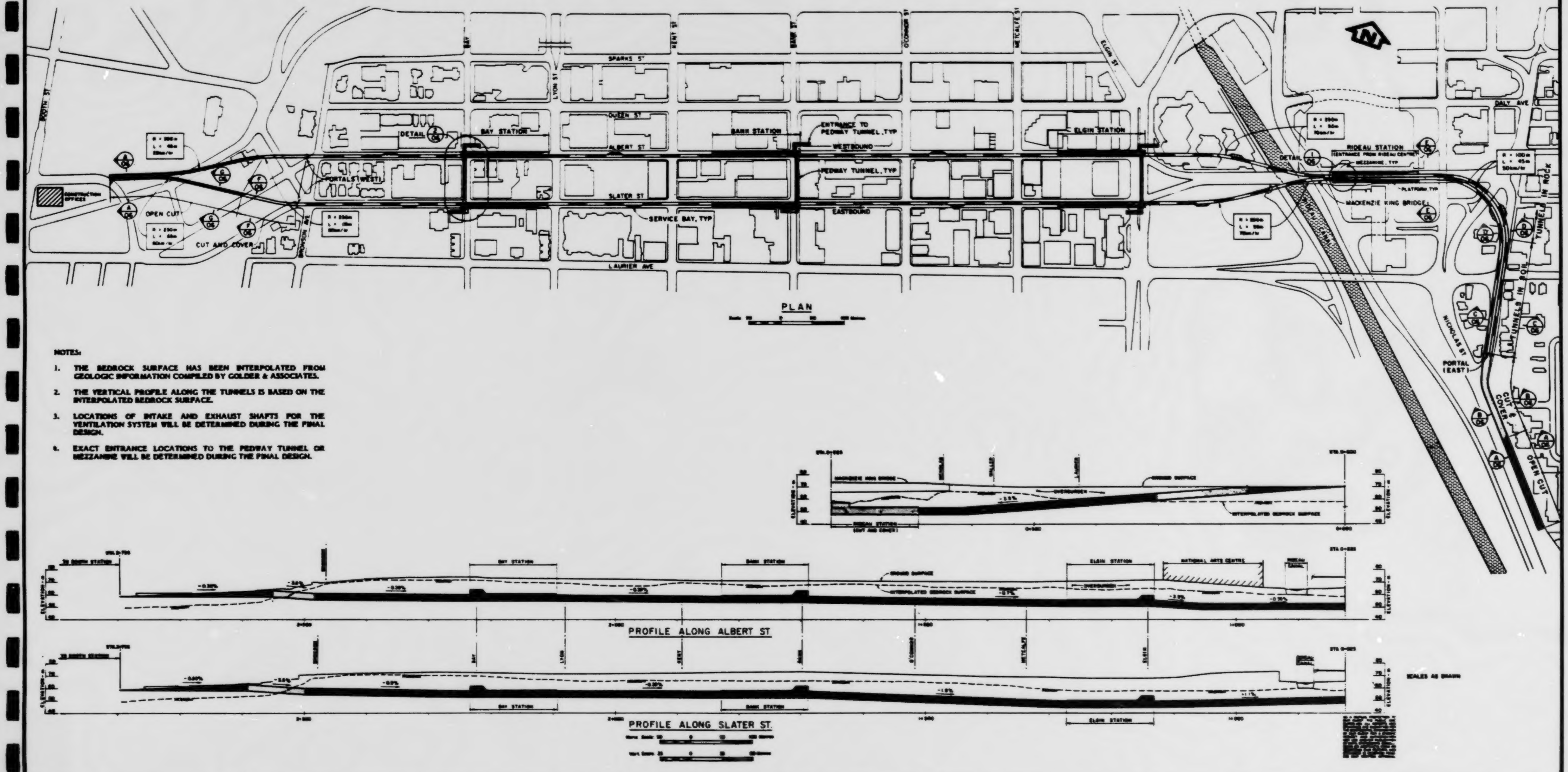
**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**SCHEME 2**
**PLAN & PROFILES**

**EXHIBIT 7.5**


BOOTH ST
BAY
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST
ELGIN ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
BRONSON AVE
DALY AVE
NICHOLAS ST
CONSTRUCTION OFFICES
OPEN CUT
CUT AND COVER
PORTALS (WEST)
DETAIL
BAY STATION
BANK STATION
ELGIN STATION
ENTRANCE TO PEDWAY TUNNEL, TYP
WESTBOUND
PEDWAY TUNNEL, TYP
EASTBOUND
SERVICE BAY, TYP
RIDEAU STATION
(ENTRANCE FROM RIDEAU CENTRE)
MEZZANINE, TYP
PLATFORM, TYP
MACKENZIE KING BRIDGE
RIDEAU CANAL
TUNNELS IN ROCK
TUNNELS IN SOIL
PORTAL (EAST)
CUT & COVER
OPEN CUT
R = 100m
L = 45m
50km/hr
PLAN
GROUND SURFACE
OVERBURDEN
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION (CUT AND COVER)
NATIONAL ARTS CENTRE
RIDEAU CANAL
ELEVATION - m
PROFILE ALONG ALBERT ST
PROFILE ALONG SLATER ST.
SCALES AS DRAWN

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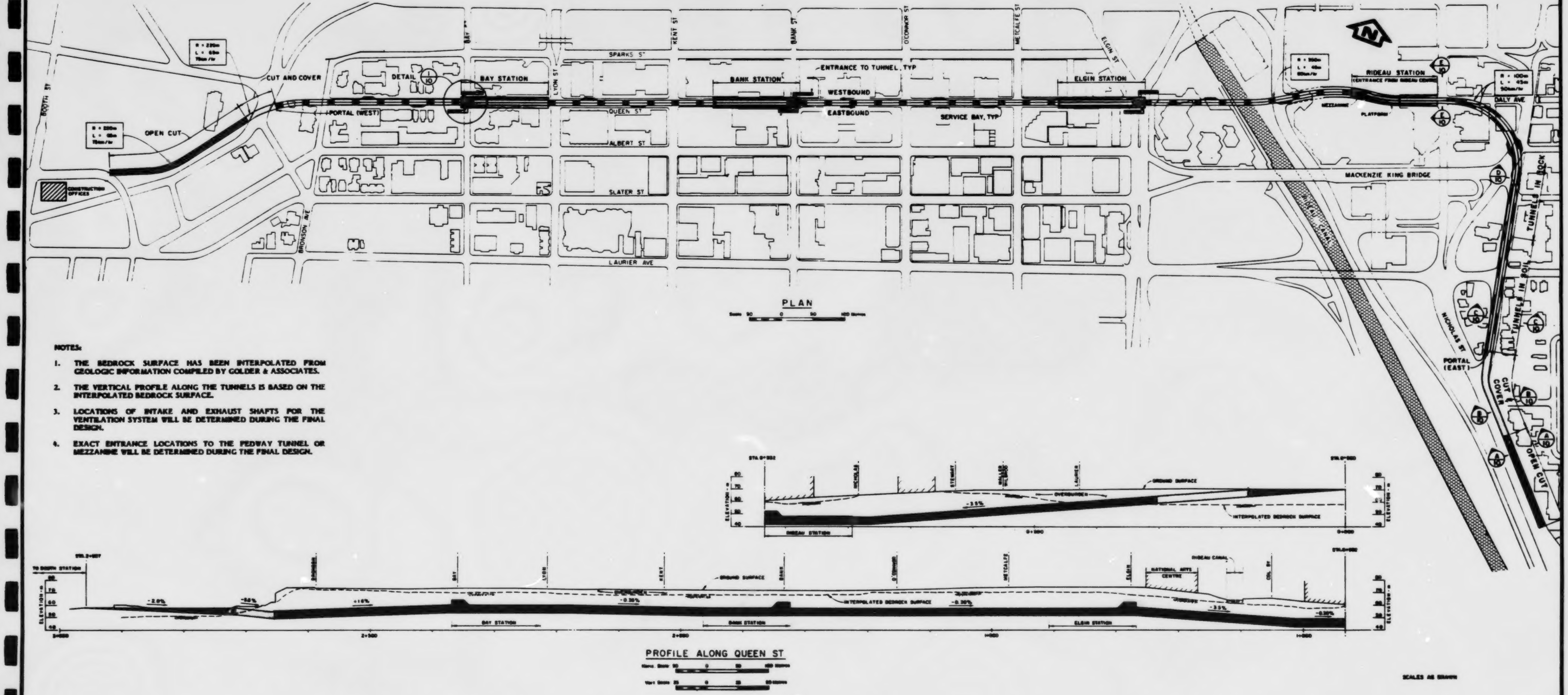
**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / **KLOHN LEONOFF**

**TUNNEL OPTION**
**SCHEME 2A**
**PLAN & PROFILES**

**EXHIBIT 7.6**


BOOTH ST
CONSTRUCTION OFFICES
OPEN CUT
CUT AND COVER
PORTAL (WEST)
DETAIL
BAY STATION
BAY ST
LYON ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
BRONSON AVE
KENT ST
BANK ST
BANK STATION
ENTRANCE TO TUNNEL, TYP
WESTBOUND
EASTBOUND
O'CONNOR ST
METCALFE ST
SERVICE BAY, TYP
ELGIN ST
ELGIN STATION
RIDEAU CANAL
MACKENZIE KING BRIDGE
RIDEAU STATION
MEZZANINE
PLATFORM
DALY AVE
NICHOLAS ST
TUNNELS IN ROCK
TUNNELS IN SOIL
PORTAL (EAST)
CUT & COVER
OPEN CUT
PLAN
GROUND SURFACE
OVERBURDEN
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION
ELEVATION - m
TO BOOTH STATION
NATIONAL ARTS CENTRE
BAY STATION
BANK STATION
ELGIN STATION
PROFILE ALONG QUEEN ST
SCALES AS SHOWN

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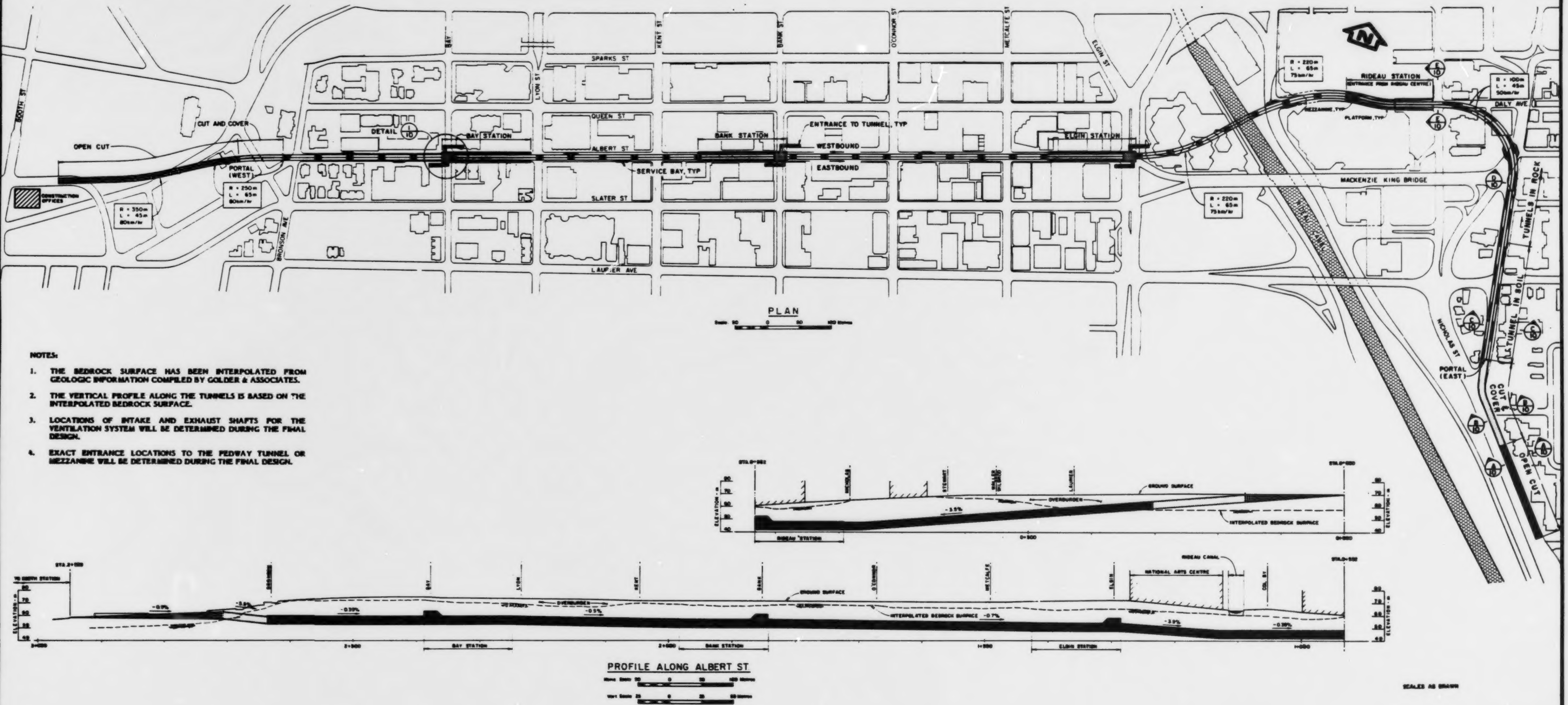
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN / KLOHN LEONOFF**

**TUNNEL OPTION**
**SCHEME 3**
**PLAN & PROFILE**

**EXHIBIT 7.7**


BOOTH ST
CUT AND COVER
OPEN CUT
CONSTRUCTION OFFICES
R = 350m
L = 45m
80km/hr
PORTAL (WEST)
R = 250m
L = 65m
80km/hr
BRONSON AVE
DETAIL 1/10
BAY
BAY STATION
LYON ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
KENT ST
SERVICE BAY, TYP
BANK ST
BANK STATION
ENTRANCE TO TUNNEL, TYP
WESTBOUND
EASTBOUND
O'CONNOR ST
METCALFE ST
ELGIN ST
ELGIN STATION
R = 220m
L = 65m
75km/hr
RIDEAU CANAL
MACKENZIE KING BRIDGE
R = 220m
L = 65m
75km/hr
N
RIDEAU STATION
ENTRANCE FROM RIDEAU CENTRE
MEZZANINE, TYP
PLATFORM, TYP
E/10
R = 100m
L = 45m
50km/hr
DALY AVE
D/10
TUNNELS IN ROCK
TUNNEL IN SOIL
NICHOLAS ST
C/10
PORTAL (EAST)
CUT & COVER
B/10
A/10
OPEN CUT
PLAN
Scale 50 0 50 100 Metres
STA.0+982
NICHOLAS
STEWART
LAURIER
GROUND SURFACE
OVERBURDEN
-3.9%
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION
0+500
STA.0+000
ELEVATION - m
90
70
60
50
40
STA.2+120
TO BOOTH STATION
-0.9%
-3.9%
-0.39%
BRONSON
BAY
LYON
KENT
OVERBURDEN
-0.5%
BANK
GROUND SURFACE
O'CONNOR
METCALFE
INTERPOLATED BEDROCK SURFACE -0.7%
ELGIN
NATIONAL ARTS CENTRE
RIDEAU CANAL
COL BY
STA.0+982
-3.9%
-0.38%
2+000
2+500
BAY STATION
2+000
BANK STATION
1+500
ELGIN STATION
1+000
PROFILE ALONG ALBERT ST
Horiz Scale 50 0 50 100 Metres
Vert Scale 25 0 25 50 Metres
SCALES AS DRAWN

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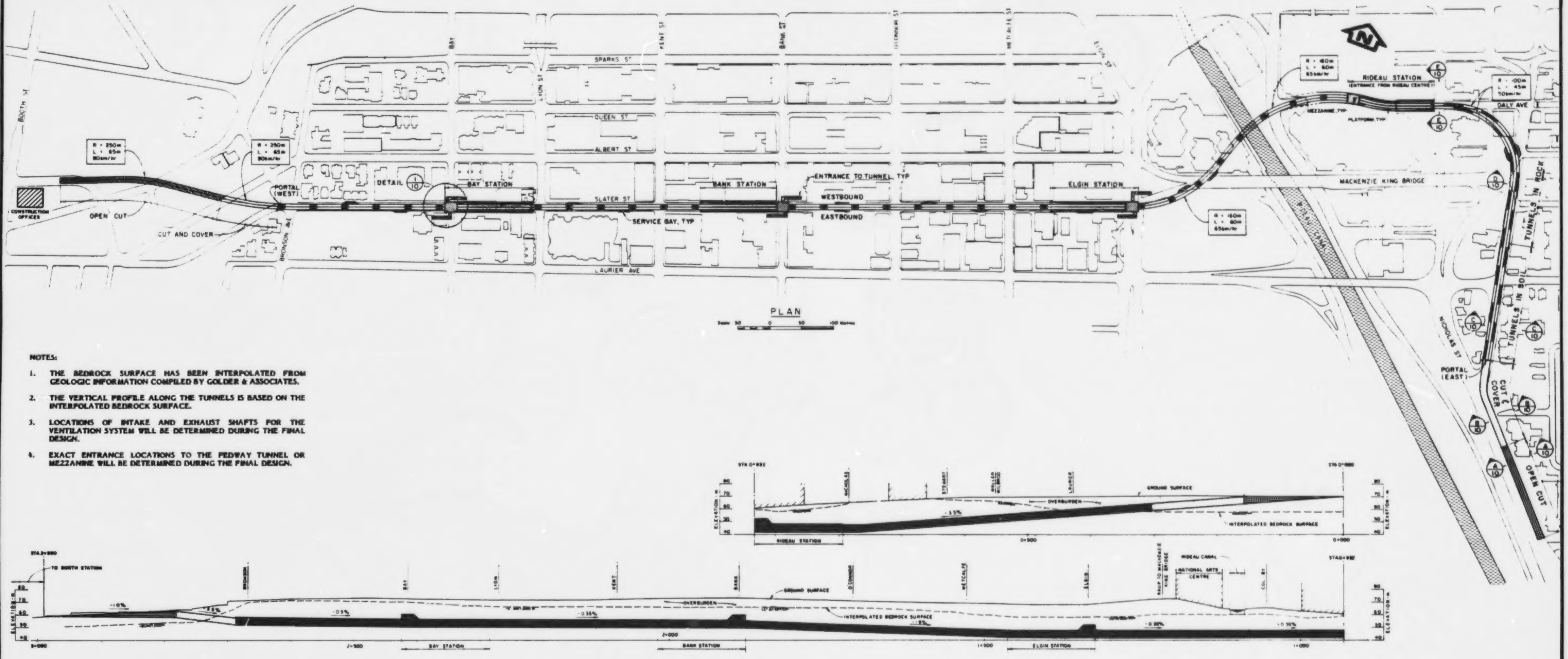
**DELCAN / KLOHN LEONOFF**

**TUNNEL OPTION**
**SCHEME 3A**
**PLAN & PROFILE**

EXHIBIT 7.8


BOOTH ST
BAY
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST
ELGIN ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
BRONSON AVE
R = 250m
L = 65m
80km/hr
CONSTRUCTION OFFICES
OPEN CUT
CUT AND COVER
PORTAL (WEST)
DETAIL
BAY STATION
SERVICE BAY, TYP
BANK STATION
ENTRANCE TO TUNNEL, TYP
WESTBOUND
EASTBOUND
ELGIN STATION
R = 180m
L = 60m
65km/hr
RIDEAU CANAL
MACKENZIE KING BRIDGE
RIDEAU STATION
(ENTRANCE FROM RIDEAU CENTRE)
MEZZANINE TYP
PLATFORM TYP
R = 100m
L = 45m
50km/hr
DALY AVE
TUNNELS IN ROCK
TUNNELS IN SOIL
NICHOLAS ST
PORTAL (EAST)
CUT & COVER
OPEN CUT
PLAN
STA 0+932
STA 0+000
NICHOLAS
STEWART
WALLER WILBROD
LAURIER
GROUND SURFACE
OVERBURDEN
-3.5%
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION
0+500
0+000
ELEVATION - m
STA 2+990
TO BOOTH STATION
-1.0%
-0.5%
-0.35%
-1.8%
-0.30%
-0.19%
BAY STATION
BANK STATION
ELGIN STATION
RIDEAU CANAL
NATIONAL ARTS CENTRE
RAMP TO MACKENZIE KING BRIDGE
COL BY
STA0+932
3+000
2+500
2+000
1+500
1+000

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**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**SCHEME 3B**
**PLAN & PROFILE**

7.2.2.2 Alignments for Schemes 4, 4A and 4B

The proposed alignments between the Campus Station and the Rideau Centre Station along MacKenzie King Bridge for Schemes 4, 4A and 4B are identical to Schemes 2 and 2A. After leaving the Rideau Centre Station, a double-lane tunnel would run beneath the bridge and then follow Queen Street, Scheme 4 **(Exhibit 7.9)**, or Albert Street, Scheme 4A **(Exhibit 7.10)**, or Slater Street, Scheme 4B **(Exhibit 7.11)**, and continue on as for Schemes 3, 3A and 3B, respectively.

### 7.2.3 Cross-over Scheme 5

The basic concept of this scheme is to provide a grade separated cross-over for the buses at the approaches to the tunnels. The scheme would allow the buses to travel east on the northerly tunnel and travel west on the southerly tunnel. Although this arrangement could be applied to all of the above mentioned schemes, it is more suited to the twin single-lane tunnel schemes.

With this scheme, the Transitway could be better integrated with the stations since a central platform concept could be developed for the stations. A pedestrian tunnel between two single-lane stations could come off the middle of the platforms and a single fare collection area would be required. However, additional cost for the construction of the cross-over structures is required. The cross-over scheme would require a down gradient of 6% (for one bus lane) at the eastern end of the corridor over a distance of 165 m. In plan the scheme is shown on **Exhibits 7.12a and 7.12b.**

### 7.2.4 Double Deck Tunnel Scheme

During the course of the concept review, a double deck tunnel was considered. The tunnel with two levels carrying the traffic in opposite directions, would have a reinforced concrete slab between the levels. At the stations the tunnel would be widened to accommodate a platform on each level. A mezzanine would be located above the upper deck.

The required vertical clearances for the two bus lanes (one above the other), a mezzanine, a minimum of 4 m of sound rock cover above the mezzanine and 4 to 5 m of existing overburden above the rock surface, resulted in the lower station platform being located at a minimum of 23.5 m below the street level.

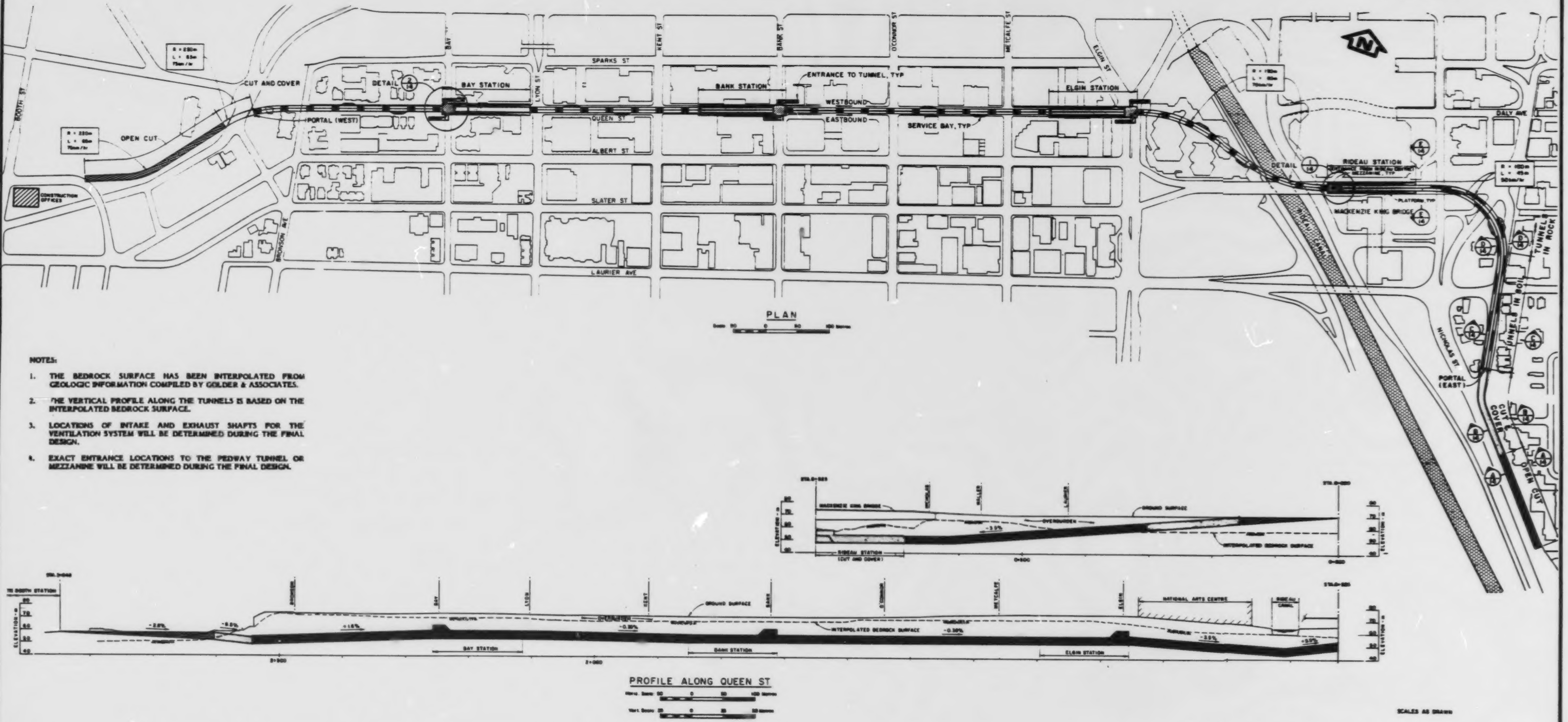
Based on a preliminary comparison with other tunnel schemes, the double deck tunnel scheme was found to be more expensive. In view of the higher capital cost of the scheme, deep stations, and the complexity of the stations, the double deck tunnel scheme was dropped from further study.

## 7.3 Tunnel and Station Geometrics and Sizes

On the basis of the existing knowledge of rock quality, requirements for minimum tunnel clearance, lane width, median and platform widths and ventilation requirements, economically and technically suitable tunnel and station geometrics and sizes were selected for both the one way and two way tunnel schemes. The one way tunnels are 6.3 m diameter with stations of 9.5 m span including a minimum 4.2 m wide platform. The one double-lane tunnel is 9.9 m span with stations of 17.6 m span including two platforms, each 4.2 m wide. For all the schemes, the platform is 110 m long.

The station geometries were also studied with a 3.5 m wide passing lane and 6.0 metre platform width. With the addition of a passing lane for a one way tunnel and wider platforms, the station span is increased to 13.5 m. Such a span would require a greater amount of support. However, with appropriate tunnel geometry and construction technique, no problems are expected as this size of a cavity is well within the state of the art for tunnelling in sound rock. In this regard, provision of a passing lane and wider platforms at the stations for the two way tunnel alternatives increases the span to 23.5 m. Such a span entails underground excavation beneath the existing buildings and

**EXHIBIT 7.9**


BOOTH ST
OPEN CUT
CUT AND COVER
CONSTRUCTION OFFICES
PORTAL (WEST)
DETAIL
BAY STATION
BAY
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST
ELGIN ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
BRONSON AVE
BANK STATION
ENTRANCE TO TUNNEL, TYP
WESTBOUND
EASTBOUND
SERVICE BAY, TYP
ELGIN STATION
RIDEAU STATION
MACKENZIE KING BRIDGE
PLATFORM, TYP
DALY AVE
NICHOLAS ST
TUNNELS IN ROCK
TUNNELS IN SOIL
PORTAL (EAST)
CUT & COVER
OPEN CUT
N
MACKENZIE KING BRIDGE
GROUND SURFACE
OVERBURDEN
-3.0%
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION
(CUT AND COVER)
ELEVATION - m
NATIONAL ARTS CENTRE
RIDEAU CANAL
INTERPOLATED BEDROCK SURFACE
-2.0%
+1.6%
-0.30%
-3.0%
BAY STATION
BANK STATION
ELGIN STATION
SCALES AS DRAWN

PLAN

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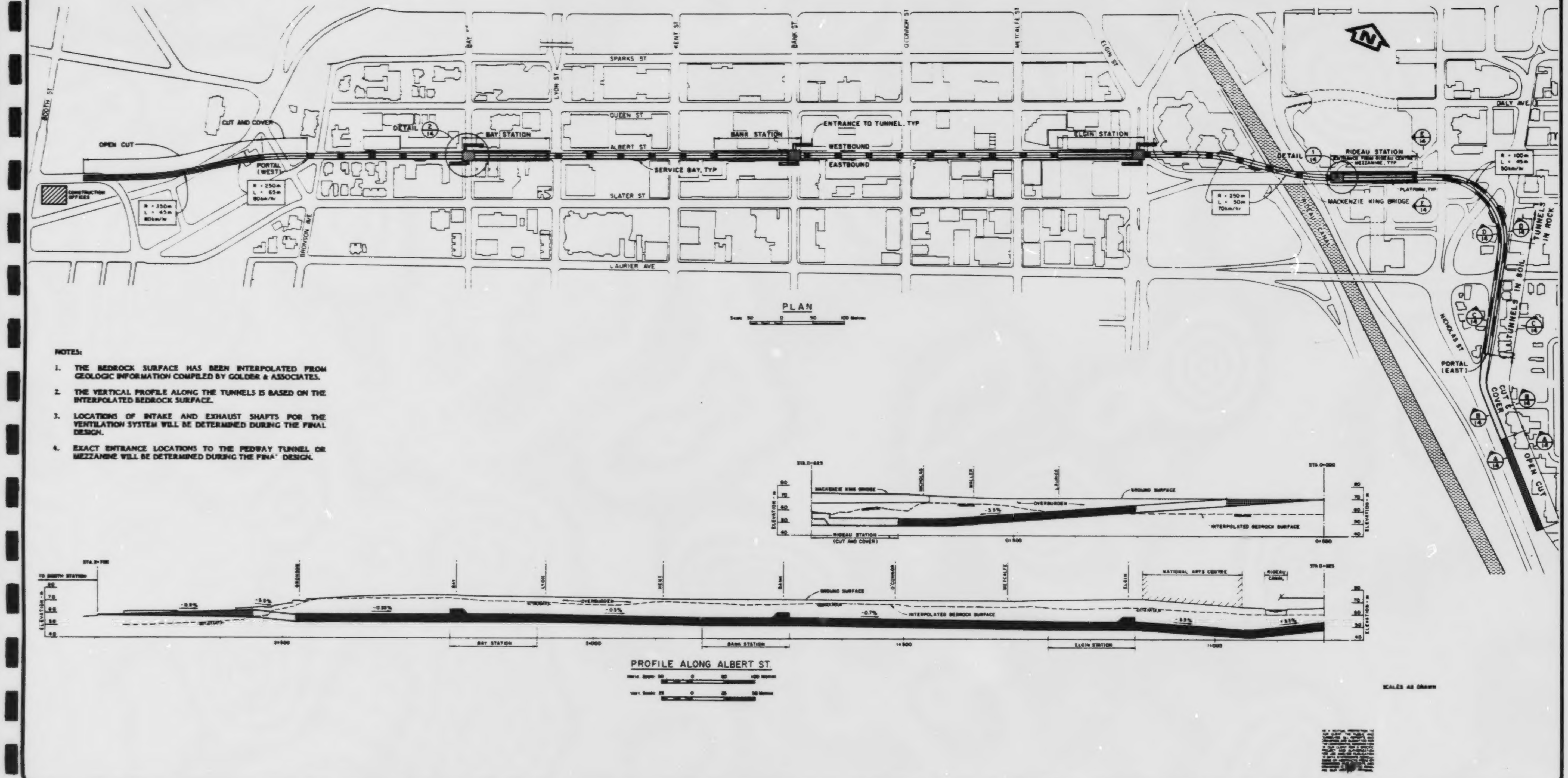
PROFILE ALONG QUEEN ST

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

**DELCAN** /KLOHN LEONOFF

TUNNEL OPTION
SCHEME 4
PLAN & PROFILE

**EXHIBIT 7.10**


BOOTH ST
CUT AND COVER
OPEN CUT
CONSTRUCTION OFFICES
PORTAL (WEST)
R = 350m L = 45m 80km/hr
R = 250m L = 65m 80km/hr
BRONSON AVE
BAY ST
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST
ELGIN ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
DETAIL 2/14
BAY STATION
BANK STATION
ELGIN STATION
ENTRANCE TO TUNNEL, TYP
WESTBOUND
EASTBOUND
SERVICE BAY, TYP
R = 250m L = 50m 70km/hr
DETAIL 1/14
RIDEAU STATION
ENTRANCE FROM RIDEAU CENTRE MEZZANINE, TYP
PLATFORM, TYP
MACKENZIE KING BRIDGE
RIDEAU CANAL
R = 100m L = 45m 50km/hr
DALY AVE
NICHOLAS ST
TUNNELS IN ROCK
TUNNELS IN SOIL
PORTAL (EAST)
CUT & COVER
OPEN CUT
N
STA.0+825
MACKENZIE KING BRIDGE
NICHOLAS
WALLER
LAURIER
GROUND SURFACE
OVERBURDEN
-3.9%
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION (CUT AND COVER)
0+500
STA.0+000
0+000
ELEVATION - m
80
70
60
50
40
STA.2+700
TO BOOTH STATION
BRONSON
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
NATIONAL ARTS CENTRE
RIDEAU CANAL
STA.0+825
-0.9%
-3.5%
-0.35%
-0.5%
-0.7%
-3.9%
+3.5%
OVERBURDEN
GROUND SURFACE
INTERPOLATED BEDROCK SURFACE
2+500
2+000
1+500
1+000
BAY STATION
BANK STATION
ELGIN STATION

PLAN

Scale 50 0 50 100 Metres

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PROFILE ALONG ALBERT ST.

Horiz. Scale 50 0 50 100 Metres

Vert. Scale 25 0 25 50 Metres

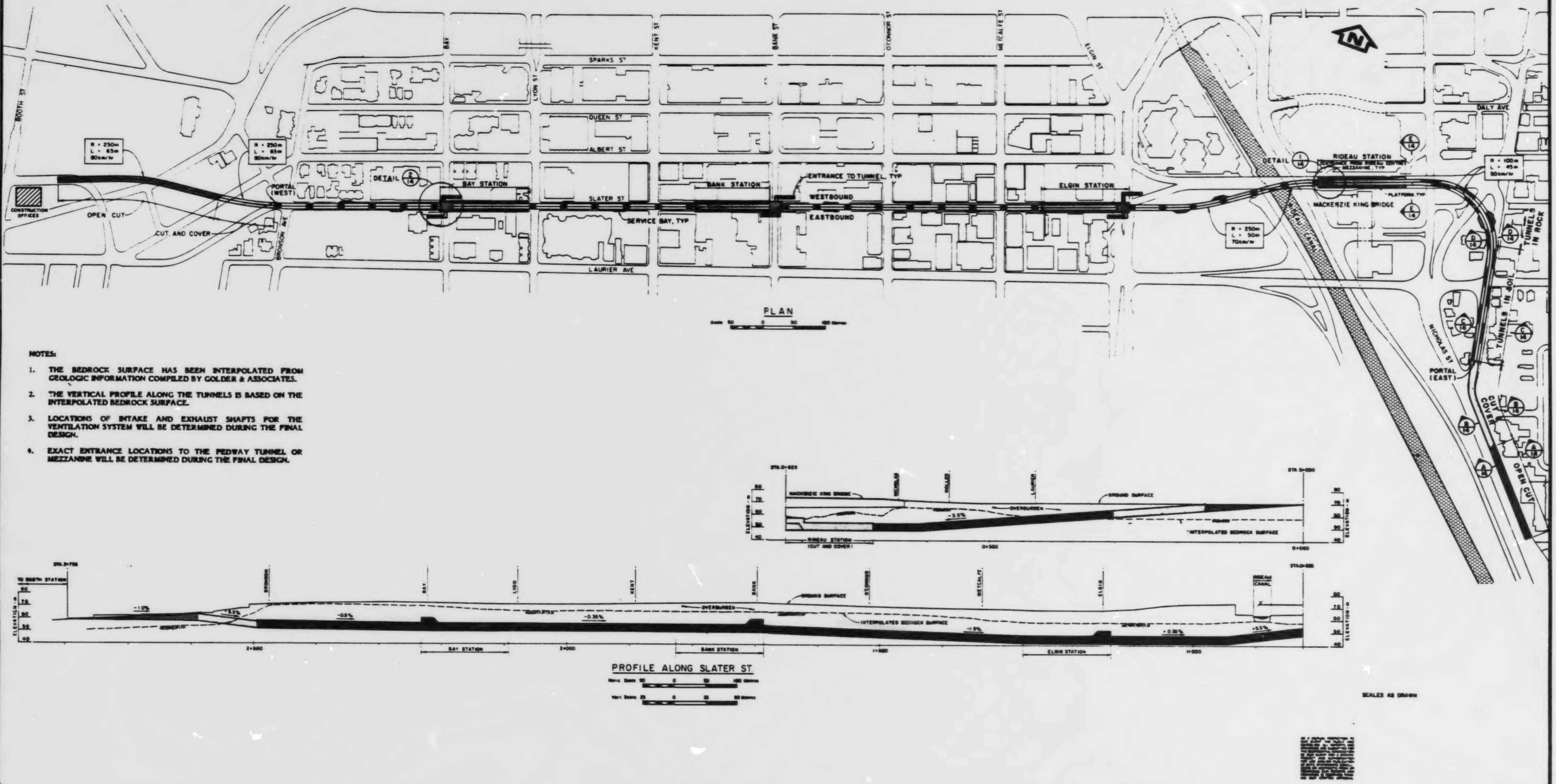
SCALES AS DRAWN

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

**DELCAN** / KLOHN LEONOFF

## TUNNEL OPTION
## SCHEME 4A
## PLAN & PROFILE

**EXHIBIT 7.11**



BOOTH ST
BAY
LYON ST
KENT ST
BANK ST
O'CONNOR ST
METCALFE ST
ELGIN ST
SPARKS ST
QUEEN ST
ALBERT ST
SLATER ST
LAURIER AVE
DALY AVE
NICHOLAS ST
BRONSON AVE
N
R = 250m
L = 65m
80km/hr
CONSTRUCTION OFFICES
OPEN CUT
CUT AND COVER
PORTAL (WEST)
DETAIL
BAY STATION
SERVICE BAY, TYP
BANK STATION
ENTRANCE TO TUNNEL, TYP
WESTBOUND
EASTBOUND
ELGIN STATION
R = 250m
L = 50m
70km/hr
RIDEAU CANAL
RIDEAU STATION
MEZZANINE, TYP
PLATFORM TYP
MACKENZIE KING BRIDGE
R = 100m
L = 45m
50km/hr
TUNNELS IN ROCK
TUNNELS IN SOIL
PORTAL (EAST)
CUT AND COVER
OPEN CUT
PLAN
GROUND SURFACE
OVERBURDEN
INTERPOLATED BEDROCK SURFACE
RIDEAU STATION (CUT AND COVER)
ELEVATION - m
TO BOOTH STATION
BAY STATION
BANK STATION
ELGIN STATION
RIDEAU CANAL
PROFILE ALONG SLATER ST
SCALES AS DRAWN

NOTES:

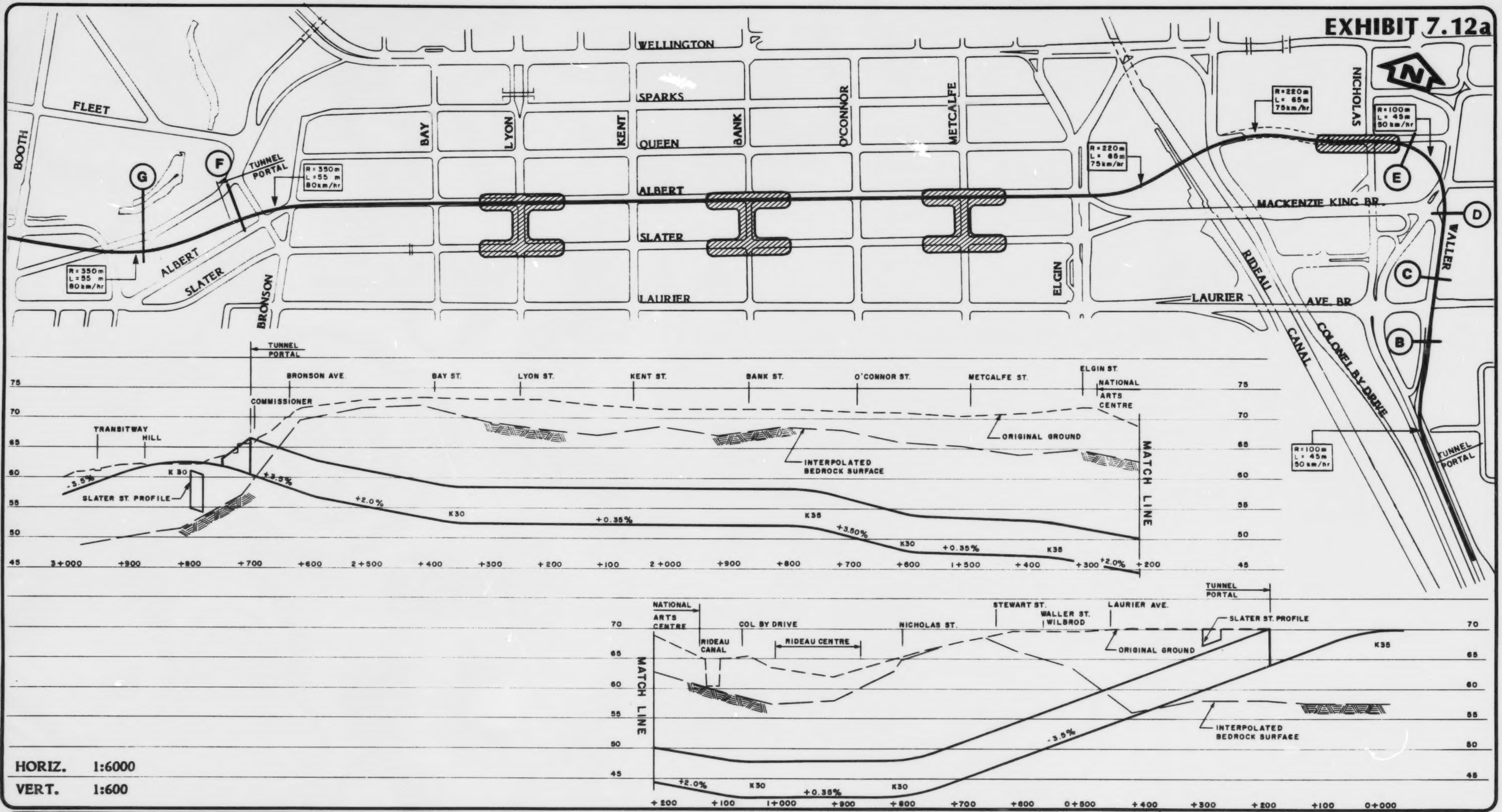
1. THE BEDROCK SURFACE HAS BEEN INTERPOLATED FROM GEOLOGIC INFORMATION COMPILED BY GOLDER & ASSOCIATES.
2. THE VERTICAL PROFILE ALONG THE TUNNELS IS BASED ON THE INTERPOLATED BEDROCK SURFACE.
3. LOCATIONS OF INTAKE AND EXHAUST SHAFTS FOR THE VENTILATION SYSTEM WILL BE DETERMINED DURING THE FINAL DESIGN.
4. EXACT ENTRANCE LOCATIONS TO THE PEDWAY TUNNEL OR MEZZANINE WILL BE DETERMINED DURING THE FINAL DESIGN.

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

**DELCAN** / KLOHN LEONOFF

TUNNEL OPTION
SCHEME 4B
PLAN & PROFILE

**EXHIBIT 7.12a**

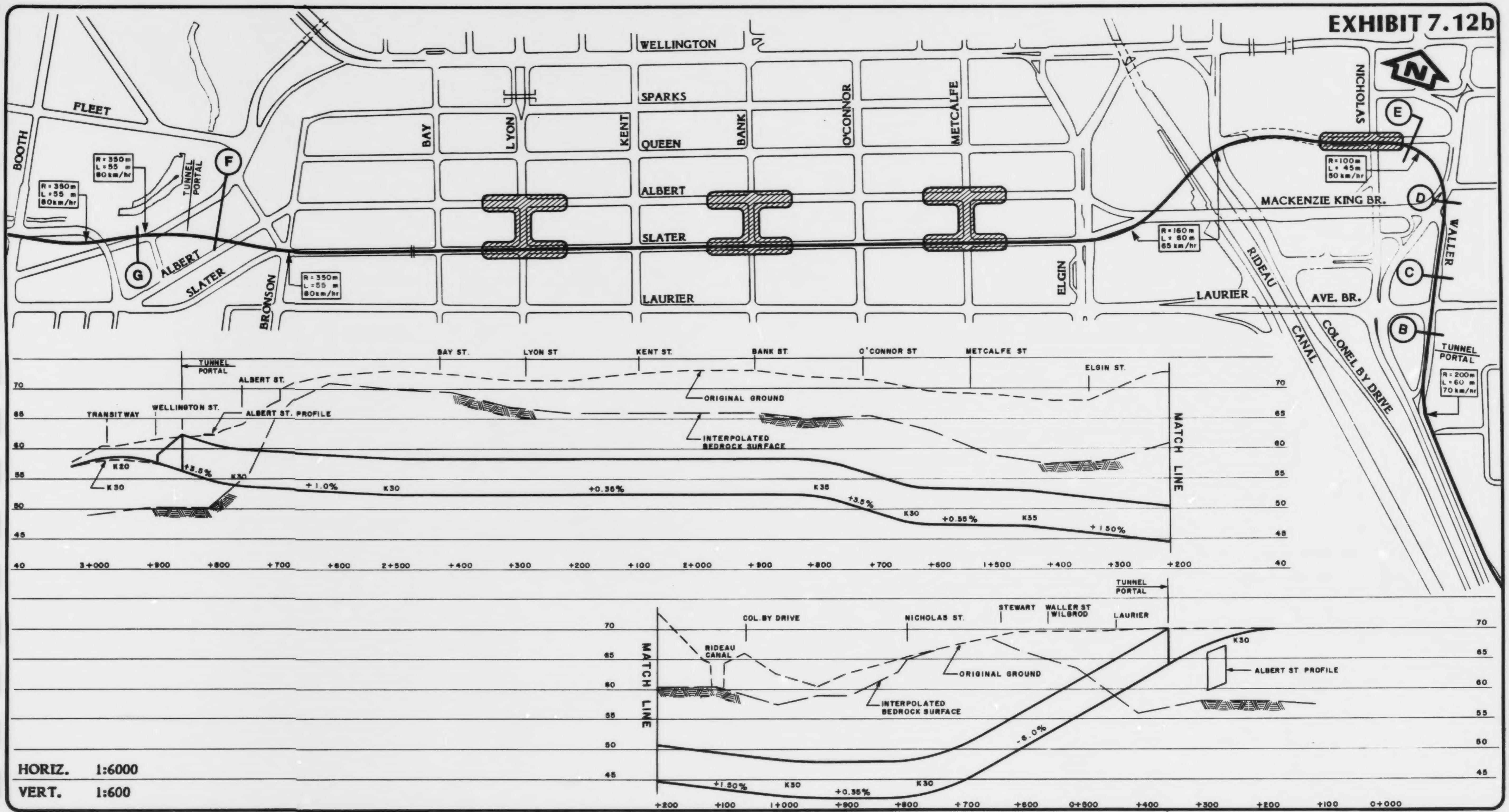

WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
FLEET
BOOTH
BRONSON
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
NICHOLAS
N
MACKENZIE KING BR.
LAURIER AVE. BR
RIDEAU CANAL
COLONEL BY DRIVE
WALLER
TUNNEL PORTAL
R=350m L=55 m 80km/hr
R=350m L=55 m 80km/hr
R=220m L=65m 75km/hr
R=220m L=65m 75km/hr
R=100m L=45m 50km/hr
R=100m L=45m 50km/hr
TUNNEL PORTAL
G
F
E
D
C
B
TUNNEL PORTAL
BRONSON AVE.
BAY ST.
LYON ST.
KENT ST.
BANK ST.
O'CONNOR ST.
METCALFE ST.
ELGIN ST.
NATIONAL ARTS CENTRE
COMMISSIONER
TRANSITWAY
HILL
K30
-3.5%
SLATER ST. PROFILE
+3.5%
+2.0%
K30
+0.35%
K35
+3.50%
K30
+0.35%
K35
+2.0%
ORIGINAL GROUND
INTERPOLATED BEDROCK SURFACE
MATCH LINE
75
70
65
60
55
50
45
3+000
+900
+800
+700
+600
2+500
+400
+300
+200
+100
2+000
+900
+800
+700
+600
1+500
+400
+300
+200
NATIONAL ARTS CENTRE
RIDEAU CANAL
COL BY DRIVE
RIDEAU CENTRE
NICHOLAS ST.
STEWART ST.
WALLER ST. WILBROD
LAURIER AVE.
TUNNEL PORTAL
SLATER ST. PROFILE
ORIGINAL GROUND
K35
INTERPOLATED BEDROCK SURFACE
-3.5%
MATCH LINE
+2.0%
K30
+0.35%
K30
+200
+100
1+000
+900
+800
+700
+600
0+500
+400
+300
+200
+100
0+000
HORIZ. 1:6000
VERT. 1:600

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY

**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**SCHEME 5**
**PLAN & PROFILE**
**ALBERT STREET**

**EXHIBIT 7.12b**


WELLINGTON
SPARKS
QUEEN
ALBERT
SLATER
LAURIER
FLEET
BOOTH
BAY
LYON
KENT
BANK
O'CONNOR
METCALFE
ELGIN
BRONSON
NICHOLAS
WALLER
MACKENZIE KING BR.
LAURIER AVE. BR.
RIDEAU CANAL
COLONEL BY DRIVE
TUNNEL PORTAL
N
A
B
C
D
E
F
G
R = 350m L = 55 m 80km/hr
R = 350m L = 55 m 80km/hr
R = 350m L = 55 m 80km/hr
R = 160m L = 60m 65 km/hr
R = 100m L = 45m 50 km/hr
R = 200m L = 60 m 70 km/hr
BAY ST.
LYON ST
KENT ST.
BANK ST.
O'CONNOR ST
METCALFE ST
ELGIN ST.
TUNNEL PORTAL
ALBERT ST.
TRANSITWAY
WELLINGTON ST.
ALBERT ST. PROFILE
ORIGINAL GROUND
INTERPOLATED BEDROCK SURFACE
MATCH LINE
K20
K30
+3.5%
K30
+1.0%
K30
+0.35%
K35
+3.5%
K30
+0.35%
K35
+1.50%
70
65
60
55
50
45
40
3+000
+900
+800
+700
+600
2+500
+400
+300
+200
+100
2+000
+900
+800
+700
+600
1+500
+400
+300
+200
TUNNEL PORTAL
COL. BY DRIVE
RIDEAU CANAL
NICHOLAS ST.
STEWART
WALLER ST WILBROD
LAURIER
ORIGINAL GROUND
INTERPOLATED BEDROCK SURFACE
ALBERT ST PROFILE
MATCH LINE
K30
-6.0%
+1.50%
K30
+0.35%
K30
+200
+100
1+000
+900
+800
+700
+600
0+500
+400
+300
+200
+100
0+000
HORIZ. 1:6000
VERT. 1:600

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / KLOHN LEONOFF

**TUNNEL OPTION**
**SCHEME 5**
**PLAN & PROFILE**
**SLATER STREET**

underpinning of buildings in the station areas. This would result in high costs and some risk of settlement of the buildings. Thus, widening of the two way tunnel at stations is not recommended. See **Exhibits 7.13 and 7.14** for typical cross-sections of the tunnel.

## 7.4 Tunnel and Station Excavation and Support Systems

### 7.4.1 Excavation Methods

The construction works of the tunnel schemes are comprised of underground excavations of the tunnels and stations (about 2350 m or 80% of the alignment length) and short lengths of the approach cuts including open-cut and cut-and-cover sections (about 620 m or 20% of the alignment length).

The open-cut and cut-and-cover portions vary in depth up to a maximum of 16 m at the tunnel portals. A large portion of the excavation is in soils which will require shoring. For these sections 100% coverage of soil faces with anchored pile and mesh and shotcrete systems has been assumed for costing purposes. For the rock portion, 100% coverage with shotcrete and pattern rock bolts has been assumed.

Parts of the tunnel are in soil (about 375 m of single-lane tunnel). It is envisaged that excavation of these headings will proceed by roadheader with immediate installation of steel sets, lagging and shotcrete, to support the excavation. These headings would be driven from the east end (Campus Station) and would be independent and proceed concurrently with the rock tunnel excavation from the west end (Booth Street). The soil tunnels will require full reinforced concrete lining as permanent support. This operation would be scheduled so as not to interfere with the tunnel boring machine (TBM) operation and would be completed prior to breakthrough from the west end.

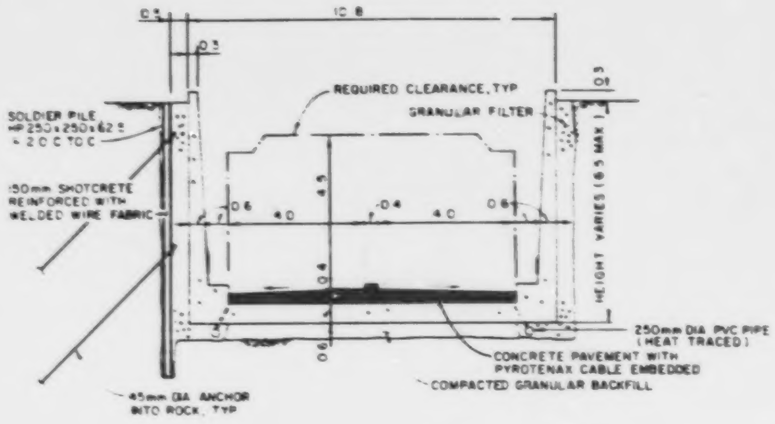
The bulk of the rock excavation for Schemes 1, 1A, 2, 2A and 5 (one way tunnels and stations) could be carried out by either a full face TBM or drill and blast technique. Costing was based on the use of a TBM as this method of excavation guarantees high production with minimum rock disturbance. It is envisaged that the support requirements for the tunnels and station platform zones will be relatively light (shotcrete/mesh/rock-bolts systems) and only the mezzanine sections of the stations are assumed to be fully lined with reinforced concrete in the arch and walls.

Second stage excavation (slashing) will be required at the stations after the primary TBM bore has been completed. Normally such slashing in rock is carried out by drill and blast method. In consideration of the urban environment and the limitations which may be imposed on the drill and blast method of slashing, preliminary inquiries were made with a TBM manufacturer as to the availability and effectiveness of mechanical excavation for enlargements. According to the manufacturer, such equipment exists, is being used in similar applications and could be modified to suit Ottawa conditions. The use of a mobile miner machine to enlarge the tunnel bores and excavate the cross pedestrian tunnels connecting the platform was included in developing the construction cost estimate.

If mechanical slashing is not effective it would impact the whole of the work instead of only the station enlargements as the whole project will be critically dependent on slashing performance. Further investigation is required to determine if mobile miners or drill and blast techniques will be the best alternative.

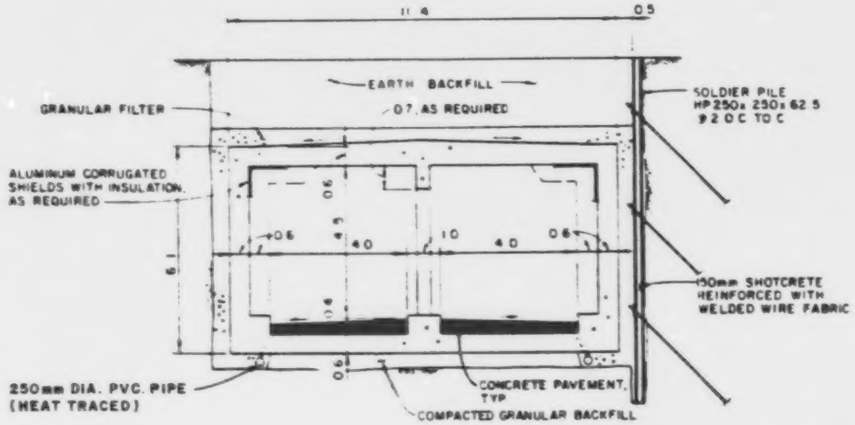
For the two way tunnel and station schemes (Schemes 3 and 4) the slashing volumes are double those required for the single-lane tunnel schemes (Schemes 1, 2 and 5). The use of two mobile miner machines to carry out the enlargements is therefore allowed in the costs to maintain a construction schedule that could be comparable to Schemes 1 and 2. From the point of view of scheduling, performance and risk, this alternative is less attractive than the one way schemes in that it does not divide the work areas in two halves for concurrent work.

**EXHIBIT 7.13**



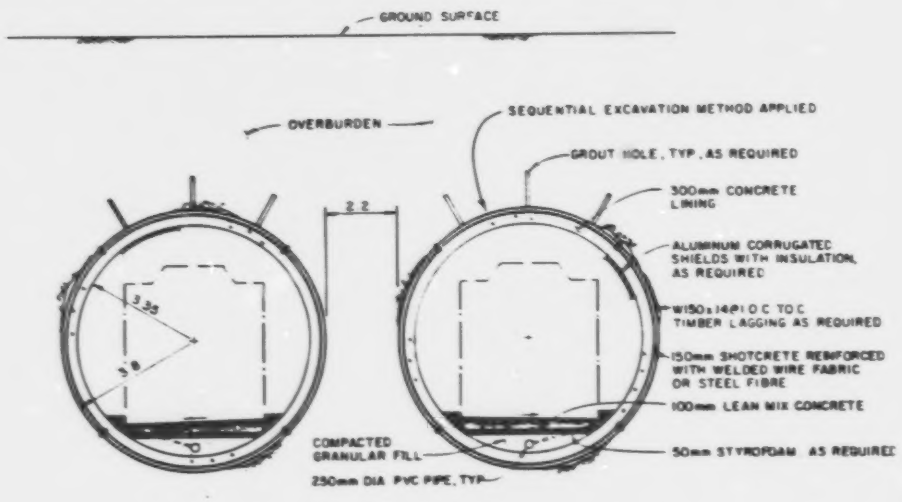
0.5
10.8
0.3
0.3
SOLDIER PILE HP 250 x 250 x 62.5 @ 2.0 C TO C
REQUIRED CLEARANCE, TYP
GRANULAR FILTER
150mm SHOTCRETE REINFORCED WITH WELDED WIRE FABRIC
0.6
4.0
4.5
0.4
4.0
0.6
0.4
HEIGHT VARIES (6.5 MAX)
250mm DIA PVC PIPE (HEAT TRACED)
0.6
CONCRETE PAVEMENT WITH PYROTENAX CABLE EMBEDDED
COMPACTED GRANULAR BACKFILL
45mm DIA ANCHOR INTO ROCK, TYP

SECTION A 01,02, 03



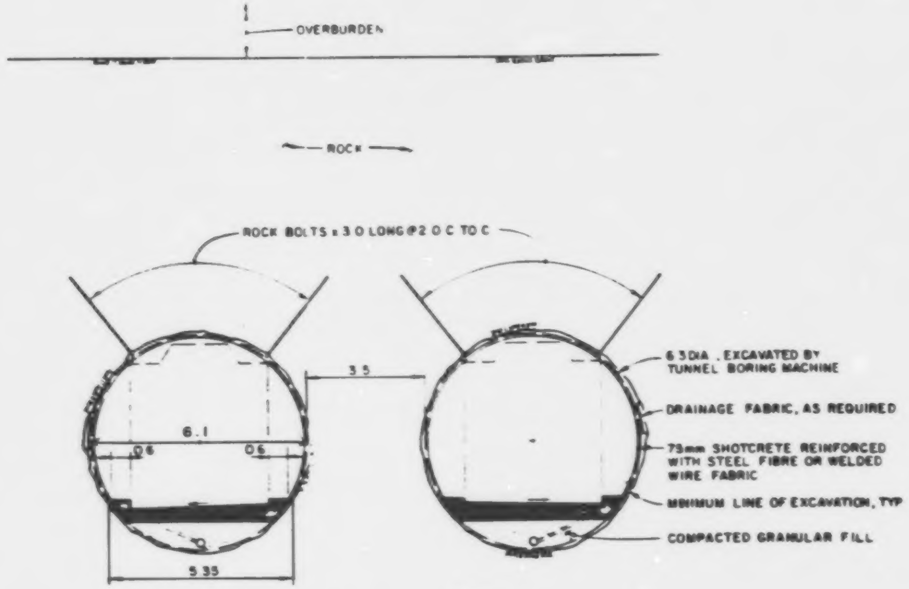
11.4
0.5
EARTH BACKFILL
GRANULAR FILTER
0.7, AS REQUIRED
SOLDIER PILE HP 250 x 250 x 62.5 @ 2.0 C TO C
ALUMINUM CORRUGATED SHIELDS WITH INSULATION, AS REQUIRED
0.6
4.5
0.6
4.0
1.0
4.0
0.6
6.1
0.4
150mm SHOTCRETE REINFORCED WITH WELDED WIRE FABRIC
250mm DIA. PVC. PIPE (HEAT TRACED)
0.6
CONCRETE PAVEMENT, TYP
COMPACTED GRANULAR BACKFILL

SECTION B 01,02, 03



GROUND SURFACE
OVERBURDEN
SEQUENTIAL EXCAVATION METHOD APPLIED
GROUT HOLE, TYP, AS REQUIRED
2.2
300mm CONCRETE LINING
ALUMINUM CORRUGATED SHIELDS WITH INSULATION, AS REQUIRED
3.35
3.8
W150 x 14 @ 1.0 C TO C TIMBER LAGGING AS REQUIRED
150mm SHOTCRETE REINFORCED WITH WELDED WIRE FABRIC OR STEEL FIBRE
100mm LEAN MIX CONCRETE
COMPACTED GRANULAR FILL
50mm STYROFOAM AS REQUIRED
250mm DIA PVC PIPE, TYP

SECTION C 01,02, 03



OVERBURDEN
ROCK
ROCK BOLTS x 3.0 LONG @ 2.0 C TO C
3.5
6.3 DIA., EXCAVATED BY TUNNEL BORING MACHINE
DRAINAGE FABRIC, AS REQUIRED
6.1
0.6
0.6
75mm SHOTCRETE REINFORCED WITH STEEL FIBRE OR WELDED WIRE FABRIC
MINIMUM LINE OF EXCAVATION, TYP
COMPACTED GRANULAR FILL
5.35

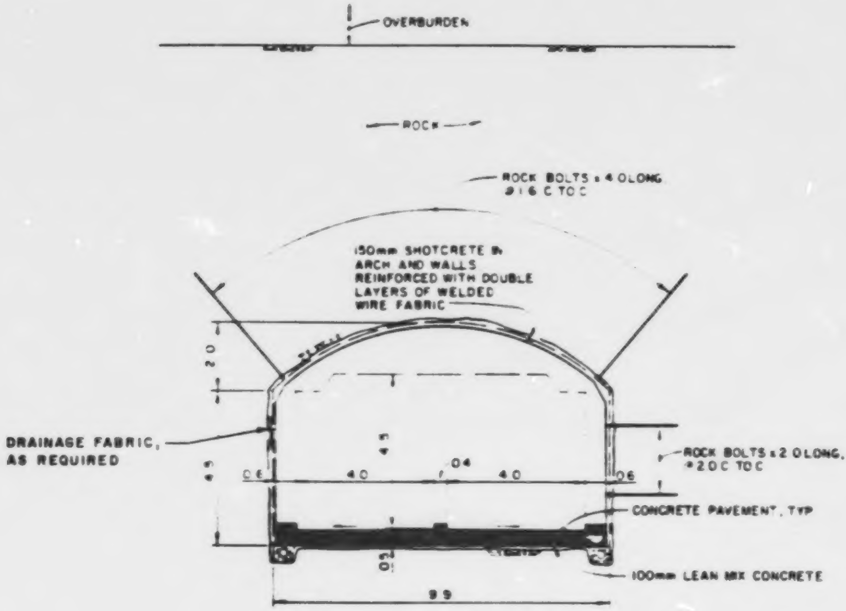
SECTION D 01,02, 03

## REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
## CENTRAL AREA TRANSITWAY
## GRADE - SEPARATION FEASIBILITY STUDY

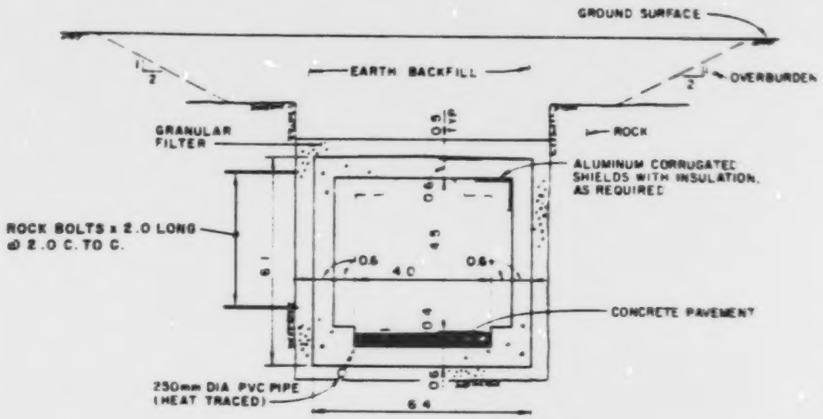
**DELCAN** / KLOHN LEONOFF

## TUNNEL OPTION
## SCHEMES 1 AND 1A
## SECTIONS

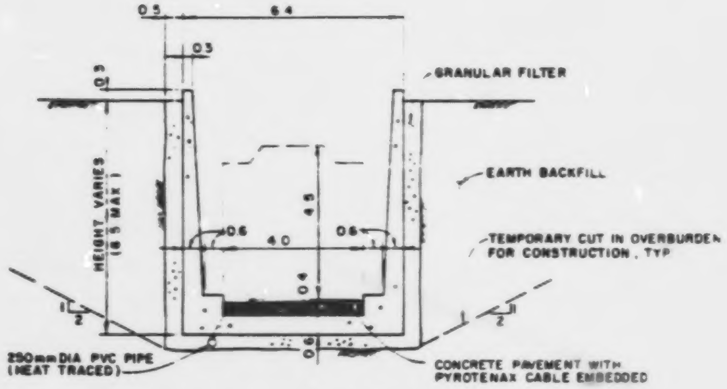
**EXHIBIT 7.14**


OVERBURDEN
ROCK
ROCK BOLTS x 4.0 LONG
@ 1.6 C TO C
150mm SHOTCRETE IN
ARCH AND WALLS
REINFORCED WITH DOUBLE
LAYERS OF WELDED
WIRE FABRIC
2.0
DRAINAGE FABRIC,
AS REQUIRED
4.5
4.5
0.6
4.0
0.4
4.0
0.6
ROCK BOLTS x 2.0 LONG,
@ 2.0 C TO C
CONCRETE PAVEMENT, TYP
0.5
100mm LEAN MIX CONCRETE
9.9

SECTION E 01,02 03


GROUND SURFACE
1
2
EARTH BACKFILL
1
2
OVERBURDEN
0.5 TYP
ROCK
GRANULAR
FILTER
ALUMINUM CORRUGATED
SHIELDS WITH INSULATION,
AS REQUIRED
0.6
ROCK BOLTS x 2.0 LONG
@ 2.0 C. TO C.
4.5
6.1
0.6
4.0
0.6+
0.4
CONCRETE PAVEMENT
250mm DIA PVC PIPE
(HEAT TRACED)
0.6
6.4

SECTION F 01,02 03


0.5
6.4
0.3
0.3
GRANULAR FILTER
EARTH BACKFILL
HEIGHT VARIES
(8.5 MAX)
4.5
0.6
4.0
0.6
TEMPORARY CUT IN OVERBURDEN
FOR CONSTRUCTION, TYP
0.4
1
2
1
2
250mm DIA PVC PIPE
(HEAT TRACED)
0.6
CONCRETE PAVEMENT WITH
PYROTENAX CABLE EMBEDDED

SECTION G 01,02 03

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN / KLOHN LEONOFF**

**TUNNEL OPTION**
**SCHEMES 1 AND 1A**
**SECTIONS**

The larger cavities of two way stations will require reinforced concrete lining as full wall and arch support. The two way tunnels will require more support than the one way tunnels. The escalator, stair and ventilation shafts to existing ground level would be carried out by cut-and-cover techniques.

### 7.4.2 Support Systems

Adequate allowance for tunnel and station support has been made at this feasibility study level. Conservative allowances have also been made in areas of faults and shear zones until such times as more detailed geologic information is available. A ground exploration program will be required before detailed engineering is undertaken.

The support systems planned for this tunnel concept were based on limited information from the previous boreholes, examination of the rock exposures at the western end of the corridor and past experience for support of tunnels in similar rock types. Permanent support for the one way tunnel (6.3 m diameter) and the station (9.5 m span) includes pattern rock bolts and shotcrete reinforced with welded wire fabric. Permanent support for the two way tunnel (9.9 m span) includes pattern rock bolts and shotcrete reinforced with welded wire fabric, whereas for the two way station, reinforced concrete lining would be required and be sensitive to rock cover and arch design. The final station widths will be dependent on the selected concept.

The concrete operations are fairly straightforward for all schemes. It is envisaged that all floors would be cast by means of concrete paving machines. Concrete-lined station arches where required will require special falsework/formwork which may be in steel or timber depending on the scheme and number of uses for each form. Concrete delivery to the working area could be by means of rubber or rail-mounted equipment leading from the work area outside the tunnel at the west end.

## 7.5 Ventilation and Safety Considerations

### 7.5.1 Ventilation Systems

The ventilation system which is more fully described in a following chapter is a semi-transverse system, which supplies fresh air at the stations and portals, and exhausts air at the midpoint between the stations and portals. For the semi-transverse system at each station, there would be two platform supply fans to provide fresh air for passengers in the station and tunnels. In addition, at each station there would be two high volume supply fans to provide ventilation air for the tunnels to control heat and contaminants generated by the buses, and to purge smoke and heat from the tunnels during a fire emergency. The exhaust fans located midway between the air supplies would be multiple fans with variable volume to match the supply fan operations.

Under normal conditions, the platform supply fans and matching exhaust fans would be in operation with a ventilation rate matching the number of passengers and the frequency of bus arrivals at the stations. Also, a portion of the tunnel supply and exhaust system would be operated periodically to control the level of heat and contaminants in the tunnels.

In a fire situation, full tunnel air supply and exhaust would be started automatically, with a portion of the air supply diverted into stairways, escalators or elevator shafts to provide a smoke free path for evacuation. The supply air would be exhausted at the midpoint between the stations. This is the same technique that would be applied for the cut-and-cover option.

### 7.5.2 Monitoring Systems and Emergency Equipment

Carbon monoxide and nitric oxide sensors would be located throughout the tunnels and stations to activate the tunnel air supply periodically and monitor the platform air supply when the pollutant concentration exceeds the desirable level. Also heat sensors placed throughout the tunnels and stations would serve to start the emergency system in the event of a fire.

Photo-electric cells at each portal of the tunnel would serve to monitor the daylight intensity and to automatically adjust the lighting intensity of the threshold lighting zones within the tunnel. This will eliminate sudden changes in light conditions and a loss of visual acuity by the bus drivers as they enter or leave the tunnel.

Fire extinguishers whould be located at the stations and at approximately 150 m intervals along the tunnels. Telephones connected to the control centre whould be located throughout the tunnels.

### 7.5.3 Portal Heating

Utilizing existing experience in the application of roadway heating to cope with snow and black ice, it is proposed to employ heating of the roadway at the approaches to the tunnels.

The basic principles for such heating provision is a Pyrotenax cable embedded in concrete for all open-cut sections and 20 m inside the cut-and-cover sections. The cable was assumed to be laid at about 150 mm centres over the full width of the roadways for costing purposes. The details of the minimum and maximum heating capacities would be examined during the final design phase. The system has been designed to operate when "black ice" conditions prevail or when snow accumulates.

All embedded drains of the open-cut and cut-and-cover sections would be "trace" heated with Pyrotenax cable.

### 7.5.4 Tunnel Drainage

Groundwater seepage would be collected by drainage fabric located on the outside of the tunnel structure. The water collected will discharge into a PVC drainage pipe and be pumped into the existing storm sewer system.

Ceiling and walls of the cut-and-cover section in the portal area would be insulated with aluminum corrugated panels filled with insulation. This will prevent ice formation from any seepage water through the roof and walls of the cut-and-cover structure.

During the design phase, a careful study and design of drainage will be undertaken to take advantage of the new technology and materials for drainage structures.

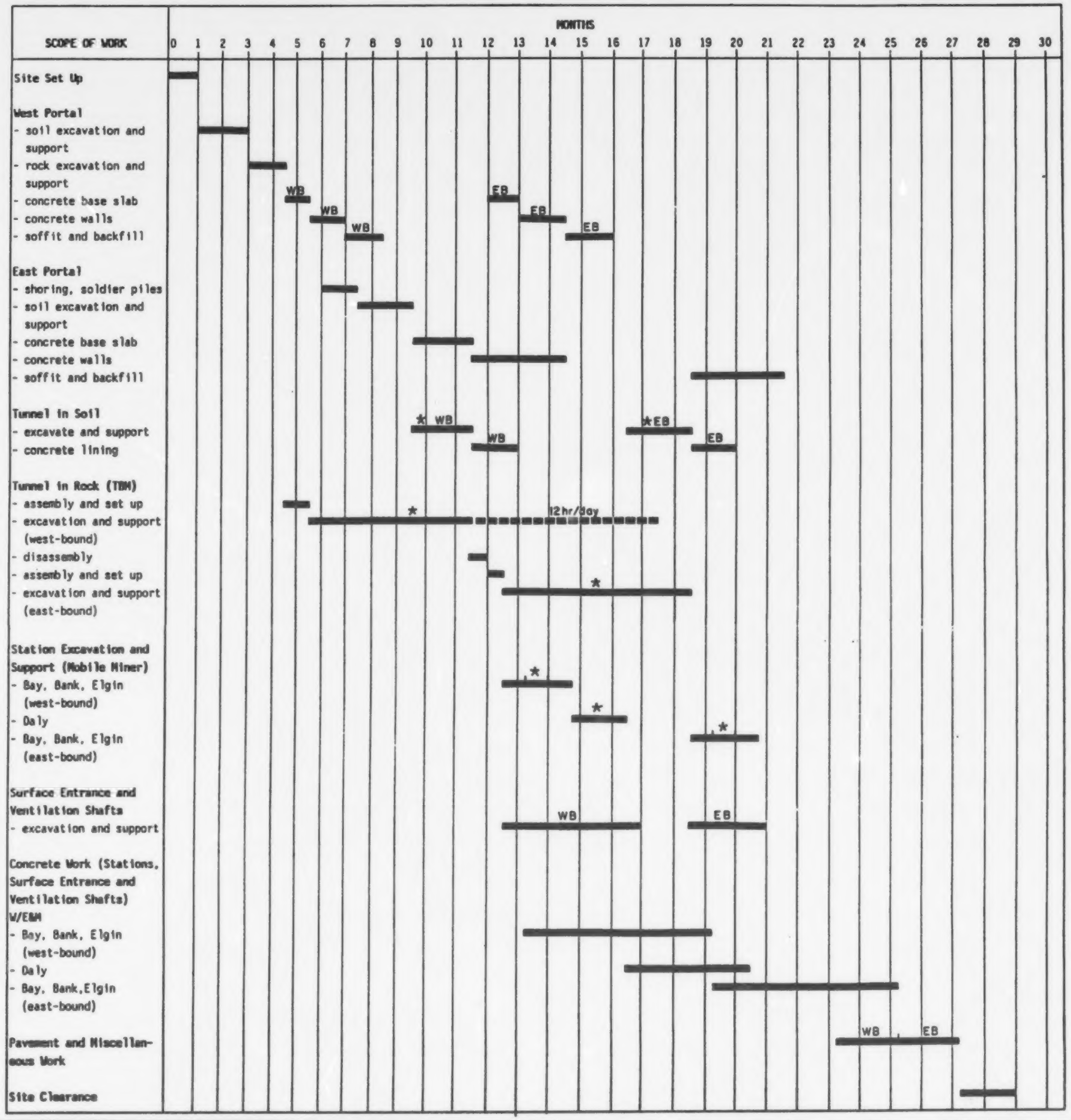
## 7.6 Construction Schedule

For the schedule **Exhibit 7.15** of one way tunnel and two way tunnel construction (Scheme 1, 2 and 5 versus 3 and 4), the variations of each scheme are not significant enough to warrant separate consideration at this stage.

The obvious start for the TBM excavation is from the west end (Lebreton Station) of the project due to the availability of a suitable work site and the small amount of work required before commencing rock excavation. For the one way tunnels the TBM would make two drives from the west end. For the two way tunnels the TBM would make only one drive with a larger portion of the excavation carried out by the mobile miner equipment.

It is estimated that construction could be completed in 29 months providing excavation can be carried out on a 24 hour/day, 5 days/week basis. Should environmental considerations restrict excavation to a 12-hour day, the construction schedule would be extended to approximatley 41 months.

## EXHIBIT 7.15



NOTES:

1. The construction schedule is based on 24 hrs/day, 5 day/week of tunnelling excavation work and 8 hrs/day, 5 days/week for all other civil, architectural and electrical/mechanical work.
2. If only 12 hrs/day are allowed for tunnelling excavation, the construction schedule would be increased to 41 months. However, 29 month schedule could be maintained by having one more TBM and one more mobile miner, i.e. approximately $5.8 million more.

*24 hrs/day applied.

WB - West Bound Traffic

EB - East Bound Traffic

REGIONAL MUNICIPALITY OF OTTAWA - CARLETON
CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN

## TUNNEL OPTION
## CONSTRUCTION SCHEDULE

## 7.7 Comparison of Schemes

### 7.7.1 General

The tunnel schemes studied have been described in earlier sections. A qualitative comparison of the various schemes has also been undertaken using the terms low, moderate and high (or favourable and unfavourable) to compare the difficulty presented by the geological conditions, risk factors, traffic disturbances and environmental impact. The relative capital costs, construction schedule, limiting velocities on curves and maximum gradients for each scheme are also included for quantitative comparison purposes. Both qualitative and quantitative comparisons for each proposed scheme are summarized in matrix form in Table 7.1. Brief descriptions of the comparison factors considered are in the following sections.

### 7.7.2 Geotechnical and Geological Considerations

The geology of the sites directly influences the design of the tunnel support systems. Rock support systems designed for a 17.6 m span (stations for Schemes 3, 3A, 3B, 4, 4A and 4B) are strongly influenced by the host rock quality, whereas designs for a 9.5 m span (stations for Schemes 1, 1A, 2, 2A and 5) or 13.5 m span for stations with a passing lane are influenced to a lesser degree. Tunnels spanning 17.6 m or greater impose a greater rock load requiring more support and hence increased costs.

The geology of the site, especially the nature and orientation of the shear and joint discontinuities, has a large influence on the rock support requirements. Another factor that influences the support requirements is the rock cover above the tunnel crown. The minimum rock cover in the mezzanine for a single-lane tunnel station is 4 m and for a double-lane tunnel station is 6 m. Such low rock cover requires sequential excavation and relatively high support measures, thus increasing costs.

### 7.7.3 Environmental Considerations

The environmental visual and noise impact of the tunnel schemes has been qualitatively compared. The tunnels themselves, of course, have no visual impact. Due to the relatively short lengths of the entrances, the visual impact of the tunnel options will be low. During the operation of the tunnel the noise from the buses will not be heard on the surface. In fact, the general noise level in the downtown area should decrease when the Transitway buses travel underground. During construction, a temporary, short-term environmental impact will be confined to the tunnel approaches, station entrances and vent shafts.

### 7.7.4 Traffic Disturbance Considerations

Traffic disturbance has been considered qualitatively for each of the schemes. Tunnelling activity will not directly affect traffic or transit operation in the project area. At the entrances, detours will be required during the construction.

The tunnelling can be carried out with a TBM and mobile miners. The operation of these machines underground will have no effect on the street traffic. Construction of tunnel scheme will not require road closure for excavation and mucking operation in the downtown area. All rock removal should be via the tunnel portal in the west end on the Lebreton Flats.

### 7.7.5 Future Flexibility of Systems

The twin tunnel scheme allows future expansion as the proposed perimeter walls of both the tunnel and the station are at a safe distance from the existing buildings and will not cause settlements of the buildings. An increase of up to 40% in the station width for the one way tunnel schemes (1, 1A, 2, 2A and 5) would not pose problems to the existing buildings. Such expansions would, however, require additional support measures inside the station such as reinforced concrete lining. The design of the final cross-

## TABLE 7.1

| SCHEMES<br>DETERMINING FACTORS | 1 | 1A | 2 | 2A | 3 | 3A | 3B | 4 | 4A | 4B | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantative Comparison | | | | | | | | | | | |
| Construction Schedule (months) | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** | 29**<br>41*** |
| Limiting Velocities on Curves (km/hr) | 50 & 75 | 50 & 65 | 50 & 70 | 50 & 70 | 50 & 75 | 50 & 75 | 50 & 65 | 50 & 70 | 50 & 70 | 50 & 70 | |
| Maximum Gradient (%) | 5.5+ | 3.5 | 5.5+ | 3.5 | 5.5+ | 5.5+ | 5.5+ | 5.5+ | 5.5+ | 5.5+ | 3.5 |
| Relative Capital Cost* | 1.00 | 1.01 | 1.00 | 1.01 | 1.05 | 1.05 | 1.06 | 1.05 | 1.04 | 1.05 | 1.01 |
| Qualitative Comparison | | | | | | | | | | | |
| Disturbance to Traffic during Construction | Low | Low | Moderate | Moderate | Low | Low | Low | Moderate | Moderate | Moderate | Low |
| Visual and Environmental Impact during Construction | Low | Low | Moderate | Moderate | Low | Low | Low | Moderate | Moderate | Moderate | Low |
| Risk of Ground Settlement of existing buildings (without support measures) | Low | Low | Low | Low | High | High | High | High | High | High | Low |
| Cost Uncertainties | Low | Low | Low | Low | High | High | High | High | High | High | Low |
| Ability to Serve Downtown (shifting southwards) | Good | Excellent | Good | Excellent | Fair | Good | Good | Fair | Good | Good | Good |
| Proximity to Rideau Centre | Excellent | Excellent | Good | Good | Excellent | Excellent | Excellent | Good | Good | Good | Excellent |
| Future Expandability of System | Excellent | Excellent | Excellent | Excellent | Poor | Poor | Poor | Poor | Poor | Poor | Excellent |
| Ease of Construction | Excellent | Excellent | Fair | Fair | Fair | Fair | Fair | Poor | Poor | Poor | Excellent |
| Geological and Geotechnical Factors | Favorable++ | Favorable++ | Favorable++ | Favorable++ | Unfavorable++ | Unfavorable++ | Unfavorable++ | Unfavorable++ | Unfavorable++ | Unfavorable++ | Favorable |
| Allowances for Safety Ways | Favorable | Favorable | Favorable | Favorable | Unfavorable | Unfavorable | Unfavorable | Unfavorable | Unfavorable | Unfavorable | Favorable |
| Inclusion of Passing Lanes at Stations | Favorable | Favorable | Favorable | Favorable | Unfavorable | Unfavorable | Unfavorable | Unfavorable | Unfavorable | Unfavorable | Favorable |

The terms Excellent, Good, Fair, Poor, Low, Moderate, High, Favorable and Unfavorable have been used for qualitative indexing of the various purposes of comparing construction environmental considerations and future expandability of the system.

* Does not include MacKenzie King Bridge replacement cost.
** Based on 24 hrs/day, 5 days/week for tunnelling excavation.
*** Based on 12 hrs/day, 5 day/week for tunnelling excavation.
+ Maximum gradient of 5.5% - varies in length between 60 m and 120 m.
++ Based on existing information.

OVERALL BEST SELECTION : SCHEMES 5

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GRADE - SEPARATION FEASIBILITY STUDY

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## COMPARISON OF VARIOUS TUNNEL SCHEMES

section can only be done when additional geological data are available. At that time, the tunnel shape can be designed to accommodate the desired width and maximize the trade-off in tunnel support versus depth of tunnel.

The potential for widening the station span for a two way tunnel scheme is limited as excavation for such an expansion would have to be carried out beneath the existing buildings. This would require underpinning and add to the schedule length and capital cost significantly.

The allowance for locating safety bays for twin tunnel schemes (1, 1A, 2, 2A and 5) is favourable. The 6.3 m span tunnel is at a safe distance from the existing buildings even with a 3 m wide safety bay. The 9.9 m span two way tunnel would require additional support measures to accommodate a safety bay.

### 7.7.6 Central Area Service Coverage

All the tunnel schemes are located in close proximity to the Rideau Centre. West of the Rideau Centre, the twin tunnels located beneath Albert Street and Slater Street offer good ability to serve the downtown area the centroid of which appears to be generally shifting southward.

### 7.7.7 Capital Cost Considerations

Due to the limited amount of available geological information, the method of excavation and support measures cannot be precisely fixed. The effect of adverse geology on support measures increases with the tunnel span. Thus the associated cost uncertainties are relatively high for a two way tunnel as compared to a one way tunnel.

### 7.7.8 Overall Best Selection for Tunnel Option

Based on the comparison of various schemes, the "Overall Best Selection" is the one way tunnels, i.e., Scheme 5. This can be inferred from qualitative comparison of the factors discussed in the previous sections. It is not intended that each of the qualitiative factors compared carry equal weight.

## 7.8 Summary and Conclusions

- The rock underlying the downtown area of Ottawa consists mainly of sound limestone which will provide an ideal material for development of a tunnelled underground scheme for the Transitway.

- Based on a comparison study of various twin tunnel and single tunnel schemes, and in consideration of a number of factors, the best overall selection is a twin tunnel scheme beneath Daly Avenue and Albert and Slater Streets. This scheme involves crossing the buses over and running westbound under Slater, and eastbound under Albert. This allows the stations to be developed so as to give the greatest passenger convenience, minimize depth of tunnel and simplify the operations at the stations.

- The construction schedule for the scheme is about 29 months based on 24 hrs./day, 5 days/week for the tunnel excavation work with one tunnel boring machine (TBM) and one mobile miner and 8 hrs./day, 5 days/week for the remaining work. If the excavation was only allowed for 12 hrs./day with one TBM the schedule length would increase to 41 months. The 12 hrs./day schedule can be shortened to approximately 30 months by employing an additional TBM and an extra mobile miner. Similar times could be expected with a drill and blast technique for construction.

- The preferred twin tunnel scheme involves underground excavation with a TBM and a mobile miner. This will cause only limited disturbance to the traffic, the existing bus lanes on Albert and Slater, or to the public at the street level. Only station access and ventilation shafts will be excavated from the surface. Due to relatively small overall dimensions of the access and ventilation shafts, these would cause limited inconvenience to the public and be confined to individual locations where traffic management techniques can be employed to reduce the impact of construction on adjacent property and street traffic.

- The geology along the corridor is based on a limited number of boreholes drilled previously to define the foundation conditions for building structures. A detailed field investigation program is required to establish the geological and geotechnical design considerations prior to completing final design.

# CHAPTER 8

# 8.0 NOISE AND VIBRATION ANALYSES

## 8.1 Introduction

This chapter presents the results of a study of the noise and vibration aspects to be considered in evaluation of the feasibility and eventual design of grade-separated options. The present Transitway operates on the surface with standard and articulated diesel buses using Slater Street and Albert Street, through the Central Business District. These operations create substantial noise exposure along the two streets of the corridor. The overall objective of the noise and vibration analyses was to determine expected changes in noise exposure due to a change to grade-separated operations and to determine the technical feasibility and impacts of the grade-separated options with respect to noise and vibration. The specific objectives included:

- Assemble information on the existing noise and vibration characteristics along the Transitway route in the Central Area, in sufficient detail for the feasibility study and for use in eventual final design analysis.
- Develop expected noise and vibration characteristics for the Initial Concept Options for the Central Area Transitway.
- Identify design criteria which should be applied to fixed facilities such as ventilation equipment.
- Ascertain design characteristics or features which should be incorporated in the Transitway design for minimizing or controlling noise and vibration.
- Determine vechicle technology information which should be considered in evaluating feasibility of the Transitway options under study.

Ambient noise and vibration surveys were performed to establish the existing conditions and projections were made of the expected noise characteristics for the three main grade-separated options. For the purposes of the analyses, these projections assumed the operation of 216 articulated buses per hour in each direction during peak periods. Recommended design criteria, design features and technology options which should be considered in the design phase were outlined.

## 8.2 Existing Conditions Survey

The noise and vibration measurements for characterizing existing conditions were primarily obtained by the Environmental Assessment Unit of the Regional Municipality of Ottawa-Carleton. The measurements were done in accordance with details and procedures established by Dr. Wilson of Wilson-Ihrig & Assoc. The purpose was to provide support information for the study, including information on street level noise and ground surface vibration at the setback lines of existing buildings, i.e., at building facades along the proposed Central Area transitway grade separated routes.

While no noise measurements were made at 10m height, to correspond with Aerial Structure Option conditions, the measurements made were adequate to characterize this option. Because of the sound reflections and reverberation due to tall buildings and the reflective nature of CBD buildings and surfaces, it is known that there is little or no difference in noise levels at street level and at 10 m height. In fact, in most Central Business District areas, the noise levels are similar for heights substantially greater than 10 m, therefore, the existing noise data obtained is fully applicable to analysis of an aerial structure option.

To accompany the noise and vibration measurements, a series of traffic counts was also performed along the existing Transitway streets during the same time period as the noise measurements were made. This provided a basis for calibrating the Central Business District traffic noise against the Ontario Ministry of Environment Road Traffic Noise Prediction Model. Prior to this study, the Prediction Model did not include provisions or corrections applicable to CBD conditions. Therefore, the overall results of the existing noise environment study include not only the evaluation of the existing conditions but also provide sufficient information to adjust the MOE Prediction Model to be specific to the Central Area Transitway Project.

### 8.3 General Summary of Analyses

Review of the buildings adjacent to the Transitway option routes indicates that there are no facilities of exceptional sensitivity to noise and vibration. There is a mix of commercial, office and hotel buildings along the main Central Area corridors, all of which can be considered to have normal CBD type sensitivity to noise and vibration. The only exceptions or buildings which may have greater sensitivity are the smaller commercial/residential type buildings at the west end of Slater, Albert and Queen Streets, which has some residential occupancy, and the Rideau Centre and University of Ottawa at the east end of the study area, which could have some sensitivity to ground-borne vibration.

The general character of the noise in the Central Area, along the existing routes is a noise exposure dominated by a mix of standard and articulated diesel buses (about 22% articulated buses) which operate at a rate of approximately 180-200 buses per hour in each direction during the peak morning and evening rush-hour periods. The present conditions produce energy equivalent noise exposure levels, $L_{eq(24)}$, in the range of 68-71 dBA and day-night noise exposure levels, $L_{dn}$ in the range of 71-75 dBA, as measured along Slater and Albert Streets. With removal of the Transitway bus traffic from these streets, the overall noise exposure values would be reduced to about $L_{eq(24)}$ = 65 dBA and $L_{dn}$ 67 dBA, a 3 to 6 dBA reduction. Similarly, the peak hour $L_{eq}$ would be reduced from about 72-74 dBA to about 66-68 dBA, a 6 dBA reduction. The extent of the actual reduction will be dependent upon how many buses actually remain on Albert and Slater Streets. Reduction in noise levels may also be experienced on other streets if bus volumes on those streets are reduced.

The evaluation included the measurement of noise spectra or frequency distribution of the noise. The original intent of this was to obtain additional information regarding the noise characteristics to provide a basis for design recommendations and criteria. These measurements also made it possible to confirm that the low frequency exhaust pulsation or fundamental tone produced by the articulated buses was a very significantly different noise compared to other vehicles and compared to standard city buses. OC Transpo was aware of this problem and was working on modifications. Subsequently this low frequency noise source was modified on the articulated buses.

The general finding from the ground vibration level measurements is that the vibration created by the street operations of the buses in most locations is below the threshold of perception and creates no impact. However, in some areas, there are pavement discontinuities or roughness, and geological conditions, which cause the vibration to reach or exceed the threshold of perception. This was found at some specific locations along Slater Street, at the MacKenzie King Bridge and at the University of Ottawa site adjacent to the Transitway at the northeast end of the study area.

The MacKenzie King Bridge is a relatively lightweight steel frame structure and there are high levels of vibration induced by the bus traffic on that bridge - well into the range of perceptible vibration. This finding is of significance with regard to the aerial structure option and underscores the importance of considering structural vibration in the design of an aerial roadway structure.

The ground at the measurement site at the University of Ottawa is apparently relatively loosely compacted fill supporting the Transitway, with the result that there are relatively high ground-borne vibration levels directly adjacent to the Transitway in this area. At the east end of Slater Street, where the rock surface is deeper than at the centre and west end of the corridor, the soil over-burden is thicker and may be a less dense material, resulting in higher amplitude, lower frequency vibration. In both these cases, the vibration could couple well to lightweight, surface founded buildings, such as residences, and cause perceptible vibration. However, large commercial buildings, with heavily loaded and deeper foundations, should not couple well and, therefore, the vibration should be of acceptable levels in such buildings.

The conclusions from the vibration observations are that, while ground-borne vibration is generally not a significant problem for at-grade operations on the bus Transitway, it certainly must be considered in the design of the grade-separated options. It is a particularly important aspect that must be considered with regard to an elevated structure option because of the potential vibration levels of the structure which could radiate noise and which could couple to adjacent buildings. Also, it is important to note that surface or cut-and-cover sections of the Transitway located in the soil overburden at the east end of the Central Area corridor, or in loosely compacted fill, could result in high levels of ground-borne vibration and potential intrusion due to that vibration.

## 8.4 Conclusions from Analysis of Noise and Vibration Study

The main conclusions from the Noise and Vibration study are:

### 8.4.1 Underground Options

- Establishment of an underground Transitway, either cut-and-cover or tunnel, will reduce the noise exposure levels along Slater Street and Albert Street by 3-6 dBA on an overall daily basis and by about 6 dBA during the peak rush-hour periods. The actual reduction will depend upon how many non-Transitway buses are permitted on Albert and Slater Streets.

- For the underground options, the only potential noise impact at adjacent Central Area buildings and facilities is that due to noise from ventilation shafts and ventilation equipment. The measurements of existing conditions, corrected for the absence of bus traffic, indicate that appropriate criteria for maximum noise from vents and ventilation equipment should be 55 dBA maximum at 15 m for steady noise, such as ventilation fans, and 65 dBA maximum at 15 m for bus passby noise transmitted to the surface via vents. If the vents must be located at or directly adjacent to buildings, lower levels may be required.

- Patrons and employees on the below grade Transitway platforms will be exposed to noise from the buses and from ventilation equipment. With appropriate sound absorption materials and sound attenuators on equipment, the sound levels will be comparable to noise levels in modern rail transit subway facilities. The sound absorption material in station areas will also control noise from patrons and provide for achieving good intelligibility of any public address or announcement systems.

- Station structures should include sound absorption treatment to provide for noise reduction within all enclosed spaces exposed to bus or ventilation equipment noise. Both the underground station acoustic treatment and gravity vent or ventilation equipment noise reduction can be done using conventional materials and designs. Conventional shaft lining and sound attenuators will reduce the noise from vent shaft openings to satisfactory levels at the surface for all parts of the underground Transitway options.

- Ground vibration for bus operations in underground options, either cut-and-cover or deep tunnel, do not generally present potential for ground-borne vibration impact, provided that the roadways are designed and constructed with smooth rolling surface without discontinuities. That is, no special requirements are indicated for most areas except that the designs should be arranged so that any drains, utility access covers or other access panels, are located away from the roadway running surfaces, either centered between or to either side of the tire running tracks. As no service cuts for utilities would be necessary, the running surface should be smooth and substantially better than any surface roadway.

- East of the Canal, where an underground structure could be founded above the rock, in the earth overburden or in fill material, it may be appropriate to consider grinding concrete running surfaces or applying an asphalt topping to provide a smooth continuous pavement to assure low vibration levels at the more sensitive areas, such as directly beneath the Rideau Centre or near the University of Ottawa.

- To accommodate the potential for possible future conversion to rail technology, the underground option designs should include sufficient depth to accommodate vibration isolation of the rails. For areas with tunnel founded in rock, it should be sufficient to provide depth to accommodate the current generation of "soft" resilient direct fixation rail fasteners. In areas where the structure is founded in highly weathered rock or in the soil overburden, sufficient depth should be incorporated to accommodate a floating slab trackbed, such as the Toronto Transit Commission double tie design.

### 8.4.2 Aerial Structure Option

- Aerial structure operations, while reducing the noise exposure along Albert Street, could result in a substantial increase in noise exposure along Slater Street, depending on the overall design of the aerial structure and the type of vehicle. Without side canopies or walls to serve as sound barriers and with buses of similar technology to the present bus fleet, the increase in noise exposure along Slater Street would be about 4-5 dBA on an overall basis and at the rush-hour periods. Further, with increased use of the articulated buses the noise intrusion would be substantially increased due to the more frequent passage of the articulated buses. Changing from the present fleet ratio to 100% articulated buses would increase this factor by approximately 4:1, which corresponds to about a 6 dB increase in the annoyance factor. Changes already made to the exhaust system of the articulated buses would reduce the above impacts slightly.

- To control noise and virbration from an elevated structure, two factors must be included in the design: (1) the sides of the structure should include a canopy or sound barrier wall as depicted on preliminary drawings of the elevated option; and (2) the structure should be a heavy concrete girder type structure to minimize structural vibration. Heavy concrete structure is needed both to prevent low frequency radiation of noise from the elevated structure and to minimize the structural vibration which can be transmitted to the ground via the support columns or to adjacent buildings at station structures.

- The side barrier wall design configuration for the aerial structure should be coordinated with selection of bus technology in order to minimize overall costs and to assure adequate control of noise exposure at buildings adjacent to the structure.

- Elevated option station structures should be designed to provide for a full vibration isolation joint between the structure and adjacent buildings. Any direct or solid connections or structural ties to adjacent buildings would result in transmission of vibration of perceptible and annoying levels in buildings so connected.

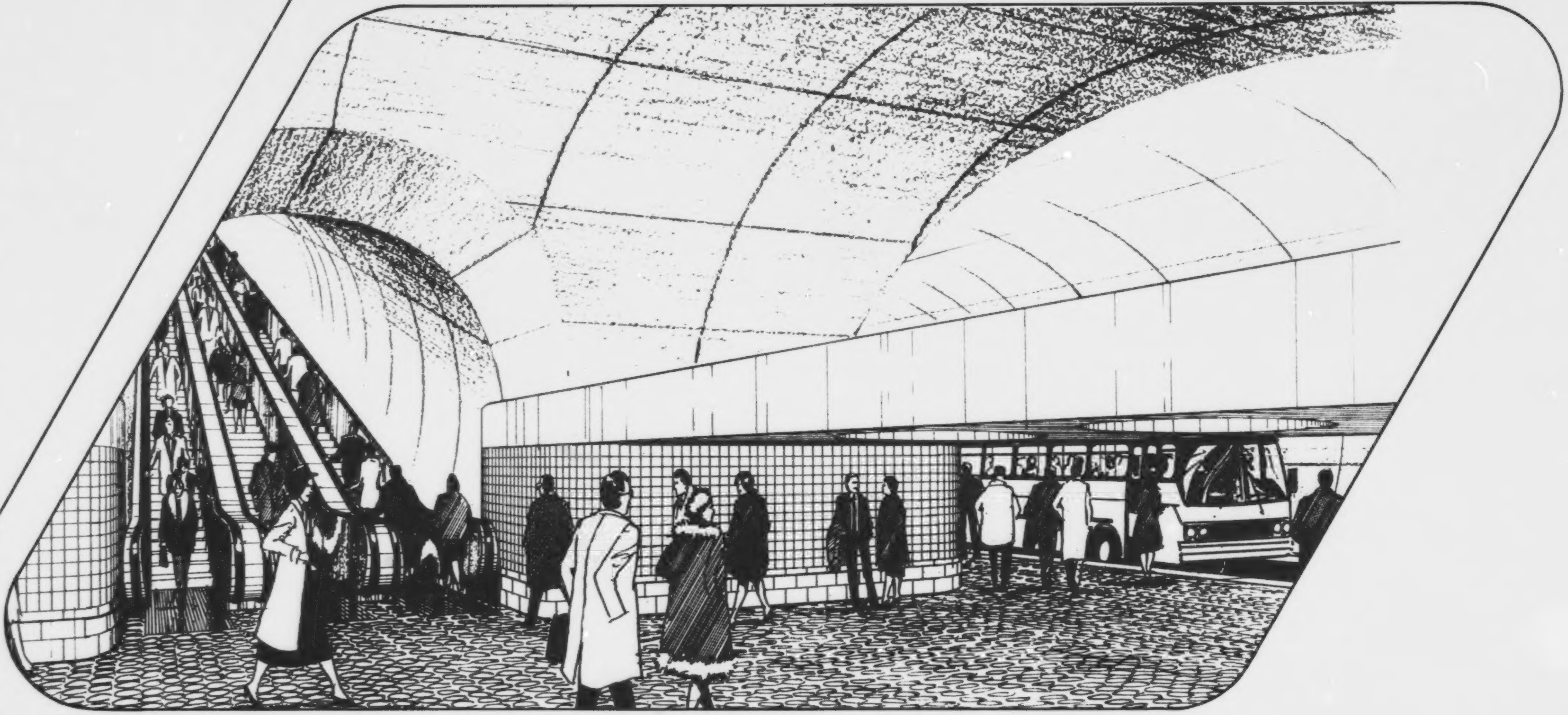
- As for stations, enclosed station areas should include sound absorption materials for control of noise from buses, ventilation equipment and patrons.

### 8.4.3 Vehicle Technology

With regard to vehicle technology, there is a consideration:

Natural gas powered vehicles have been demonstrated in limited tests to be 2-5 dBA quieter than conventional diesel buses for identical conditions. The use or eventual conversion to such vehicles would be of considerable value in reducing noise from the elevated structure option and for reducing passenger and employee noise exposure in the underground options.

Similar benefits may also be obtained from vehicles using electric power systems.



# CHAPTER 9

# 9.0 PRIMARY VENTILATION AND VEHICLE/FUEL ANALYSIS

## 9.1 General

The elevated option did not include a completely covered deck and therefore does not require a primary ventilation system, although some local ventilation will be required at stations to protect passages and service rooms from exhaust fumes. This section, therefore, refers to the underground cases only.

## 9.2 Purpose of Ventilation System

The ventilation system has a number of functions, the chief ones being:

- supply of fresh air
- removal of bus exhaust fumes
- removal of heat generated by buses and electrical equipment
- removal of heat and fumes during a fire emergency
- provision of a smoke-free path for passengers and staff during evacuation of the Transitway during a fire emergency.

The last two functions require the greatest air volume and are the most severe case. For this reason, these functions establish the size of the ventilation equipment even though demand on the system for this function would rarely occur.

The supply of fresh air and removal of bus exhaust fumes is the primary function of the ventilation system. The volume of air handled will vary with the number of buses using the Transitway. The volume, toxicity and odor of the pollutants in the bus exhausts will also be a key factor in determining the amount of air to be supplied and exhausted. Three options have been considered for bus engines and the pollutants in the exhaust for each engine are shown in Table 9-1.

The fresh air supply for the Transitway should be drawn from points about 3 metres or more above the surface steets. This air will contain some pollutants released by the surface traffic resulting in the ambient air quality shown in Table 9.2. In station areas where the public is moving and waiting for buses, the air criteria should meet the Ontario Ambient Air Quality Criteria as shown in Table 9-3.

TABLE 9.1

EXHAUST POLLUTANTS

| | | |
|---|---|---|
| Compressed Natural Gas Engine with Catalytic Converter | | |
| Nitrogen Oxides | ($NO_x$) | 0.62 g/BHP-HR[1] expressed as $NO_2$ |
| Carbon Monoxide | (CO) | 4.47 g/BHP-HR |
| Hydrocarbons | (HC) | 0.28 g/BHP-HR expressed as $CH_4$ |
| Suspended Particulate | (SP) | 0.05 g/BHP-HR |
| Well-maintained Diesel Oil Engine | | |
| Nitrogen Oxides | ($NO_x$) | 6.25 g/BHP-HR expressed as $NO_2$ |
| Carbon Monoxide | (CO) | 3.22 g/BHP-HR |
| Hydrocarbons | (HC) | 1.51 g/BHP-HR expressed as $CH_4$ |
| Suspended Particulate | (SP) | 0.57 g/BHP-HR |
| 1994 Standard - EPA - Diesel Oil Engine | | |
| Nitrogen Oxides | ($NO_x$) | 5.0 g/BHP-HR expressed as $NO_2$ |
| Carbon Monoxide | (CO) | 15.5 g/BHP-HR* |
| Hydrocarbons | (HC) | 1.3 g/BHP-HR expressed as $CH_4$ |
| Suspended Particulate | (SP) | 0.1 g/BHP-HR |

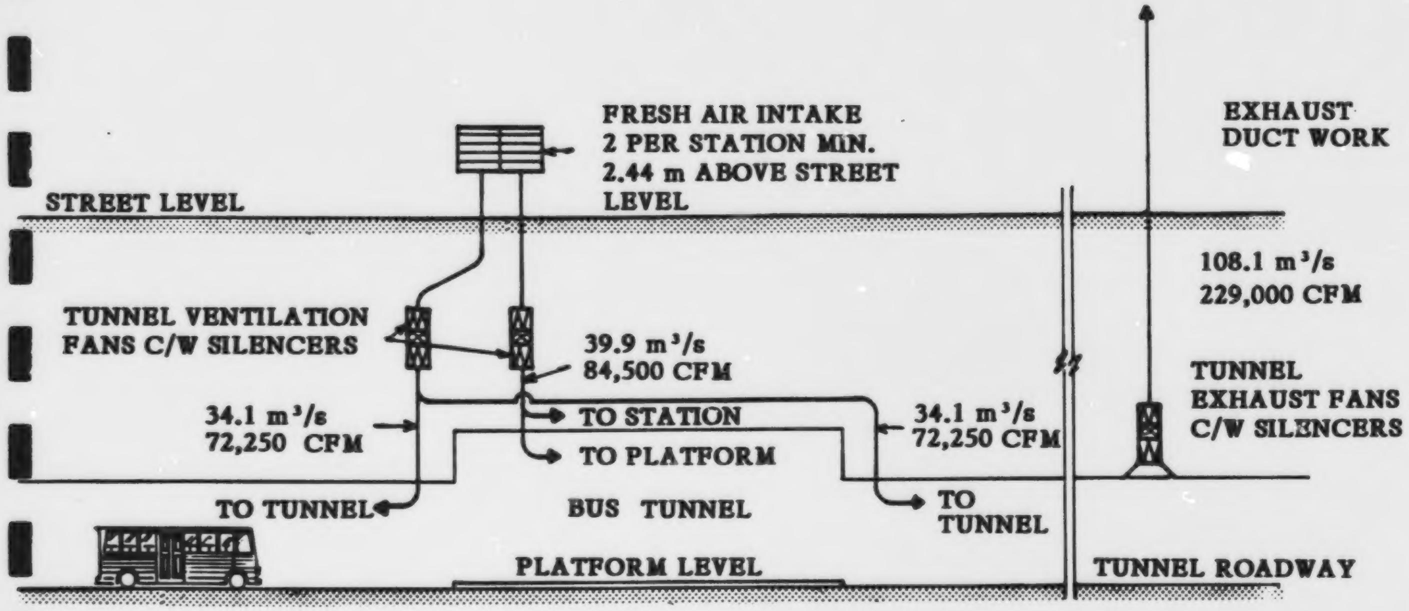
* This figure for CO is established for the EPA standard as a maximum. CO in the exhaust of Diesel Oil engines should remain in the 3 to 4 mg/BHP-HR.

[1] Brake Horsepower/Hr.

## 9.3 Ventilation Scheme

**Exhibit 9-1** illustrates the basic ventilation concept. Fresh air is supplied and distributed in the station control, passage and platform areas as well as the bus lanes. Air is exhausted from the Transitway through ventilation shafts

**EXHIBIT 9.1**


FRESH AIR INTAKE
2 PER STATION MIN.
2.44 m ABOVE STREET LEVEL
EXHAUST DUCT WORK
STREET LEVEL
108.1 m³/s
229,000 CFM
TUNNEL VENTILATION FANS C/W SILENCERS
39.9 m³/s
84,500 CFM
TUNNEL EXHAUST FANS C/W SILENCERS
34.1 m³/s
72,250 CFM
TO STATION
34.1 m³/s
72,250 CFM
TO PLATFORM
TO TUNNEL
BUS TUNNEL
TO TUNNEL
PLATFORM LEVEL
TUNNEL ROADWAY

UNDERGROUND OPTIONS
VENTILATION CONCEPT

### TABLE 9.2

### AMBIENT AIR QUALITY
### FRESH AIR SUPPLY TO THE TRANSITWAY

| | ppm (parts/million) | mg/m$^3$ (milligrams/cubic metre) |
|---|---|---|
| Nitrogen Oxides $NO_x$ | 0.05 | 0.09 |
| Carbon Monoxide CO | 2.00 | 2.30 |
| Hydrocarbons HC | 1.60 | 1.06 |
| Suspended Particulate SP | | 0.05 |

### TABLE 9.3

### DESIGN AIR QUALITY CRITERIA IN STATIONS*
### POLLUTANT LIMITS

| | ppm | mg/m$^3$ |
|---|---|---|
| Nitric Oxide NO | 25.0 | 30.0 |
| Nitrogen Dioxide $NO_2$ | 3.0 | 5.6 |
| Carbon Monoxide CO | 35.0 | 40.0 |
| Hydrocarbons HC | 10.0 | 6.6 |
| Suspended Particulate SP | | 1.0 |

* Based on Ontario Ambient Air Quality Criteria.

located mid-way between stations and between the end stations and the portals.

The air volumes given are for a fire emergency, when maximum ventilation is required. Under normal bus operations, fan operation can be reduced in steps to match the number of vehicles and the amount of pollutants produced in the tunnel. The fans would operate at relatively high capacity for approximately 6 hours each weekday or 30 hours per week. They would operate at reduced capacity for 70 hours per week and would shut down completely during night hours or 68 hours per week. There may be scope for greater variation in operation depending on the amount of exhaust fumes being generated at any one time. Adjustments would be made in response to readings from sensing equipment located in the underground area.

### 9.4 Ventilation Shafts

Intake and exhaust shafts will be required at points along the Transitway. **Exhibit 9.2** shows possible shaft locations. These locations are based on single lane tunnels on Queen and Albert Streets. Similar locations must be identified as part of later design studies for Slater Street.

Rowan Williams Davies & Irwin Inc., in their study of exhaust locations, indicate that these are unlikely to cause air quality problems on the street and, at some points, air quality can be expected to be improved. However, discharge air may present local problems in buildings with operable windows or adjacent air intakes. The use of wind tunnel modelling during the design process is recommended to examine the impact of ventilation system discharges. Many design solutions are available to locate discharge points in appropriate locations.

**Exhibit 9.3** is a preliminary sketch of a possible exhaust structure. The shape and appearance of the discharge can be varied to suit the actual site conditions. Some underground transit facilities have incorporated discharge shafts into the design of adjacent structures and exhaust the air at roof top levels, leaving no trace of a visible structure.

### 9.5 Ventilation Equipment

Axial flow fans with silencers would be provided at each station, supplying air to the platform and other areas of the station. Air would be distributed along the platform in a duct which can also be utilized for support of platform lighting, signs and public address speakers.

Exhaust fans would be of the axial flow type equipped with silencers on both the intake and discharge sides.

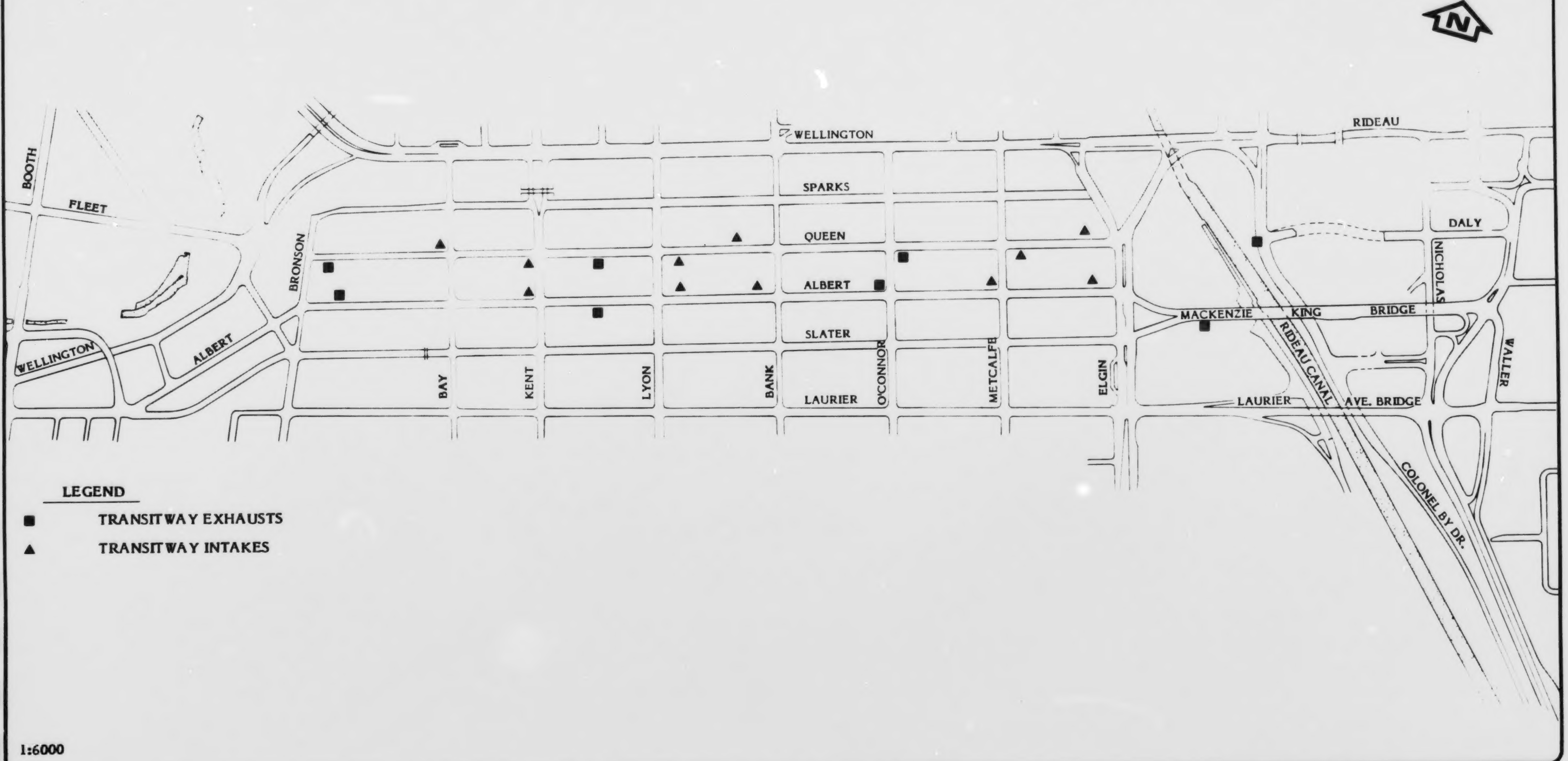
Fans would be of various sizes and operating speeds to allow varying rates of air movement. Ventilation rates would be controlled on a time basis according to the bus volumes. The air quality level in the Transitway would be continuously monitored and the time control would be over-ridden if pollution exceeded an acceptable level. Fire detectors in the Transitway would initiate an emergency ventilation program in case of fire.

### 9.6 Future Work

The analysis of the primary ventilation system was based on preliminary plans for a number of different alignments and types of construction. A number of studies and investigations should be undertaken during later design studies to refine the ventilation requirements. These are as follows:

- Location of ventilation shafts and design of these structures to fit into the street and building areas.
- Wind tunnel modelling of the Central Area to ascertain the impact of exhaust discharges on surrounding buildings.
- Landscaping and architectural treatment of ventilation shafts to fit into the streets.

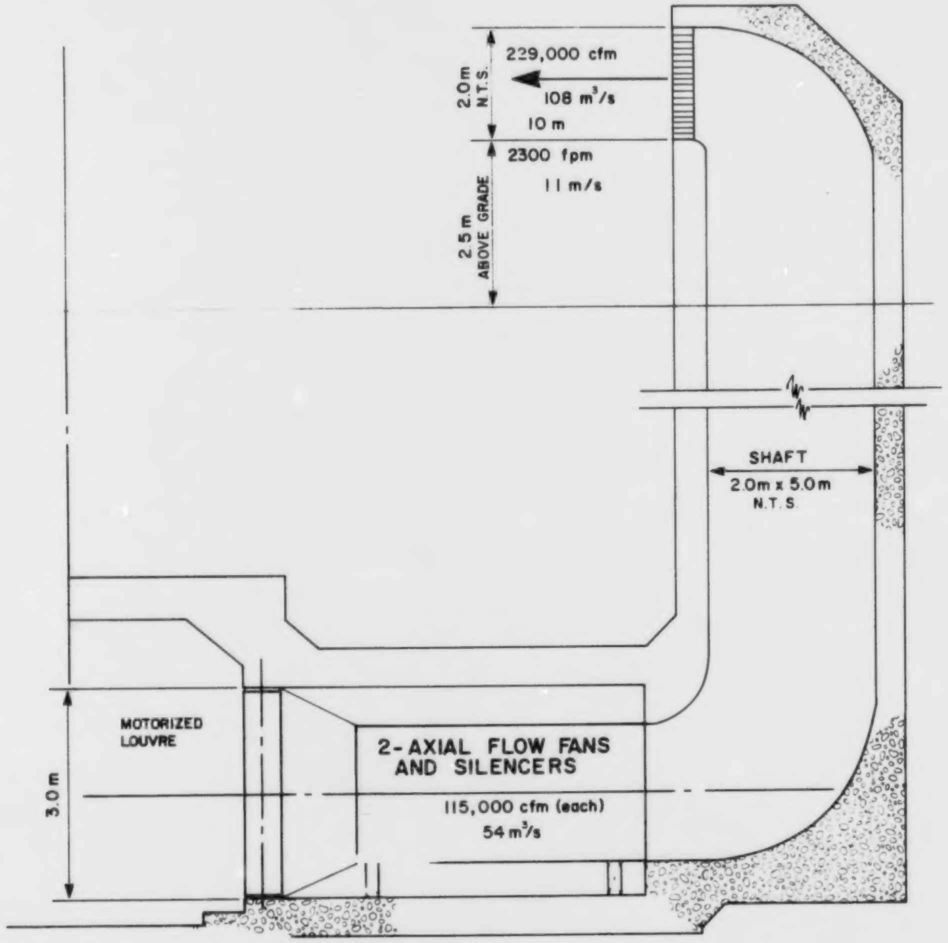
**EXHIBIT 9.2**


WELLINGTON
RIDEAU
SPARKS
QUEEN
DALY
BOOTH
FLEET
BRONSON
ALBERT
NICHOLAS
MACKENZIE KING BRIDGE
SLATER
WELLINGTON
ALBERT
RIDEAU CANAL
WALLER
BAY
KENT
LYON
BANK
LAURIER
O'CONNOR
METCALFE
ELGIN
LAURIER AVE. BRIDGE
COLONEL BY DR.
N
LEGEND
■ TRANSITWAY EXHAUSTS
▲ TRANSITWAY INTAKES
1:6000

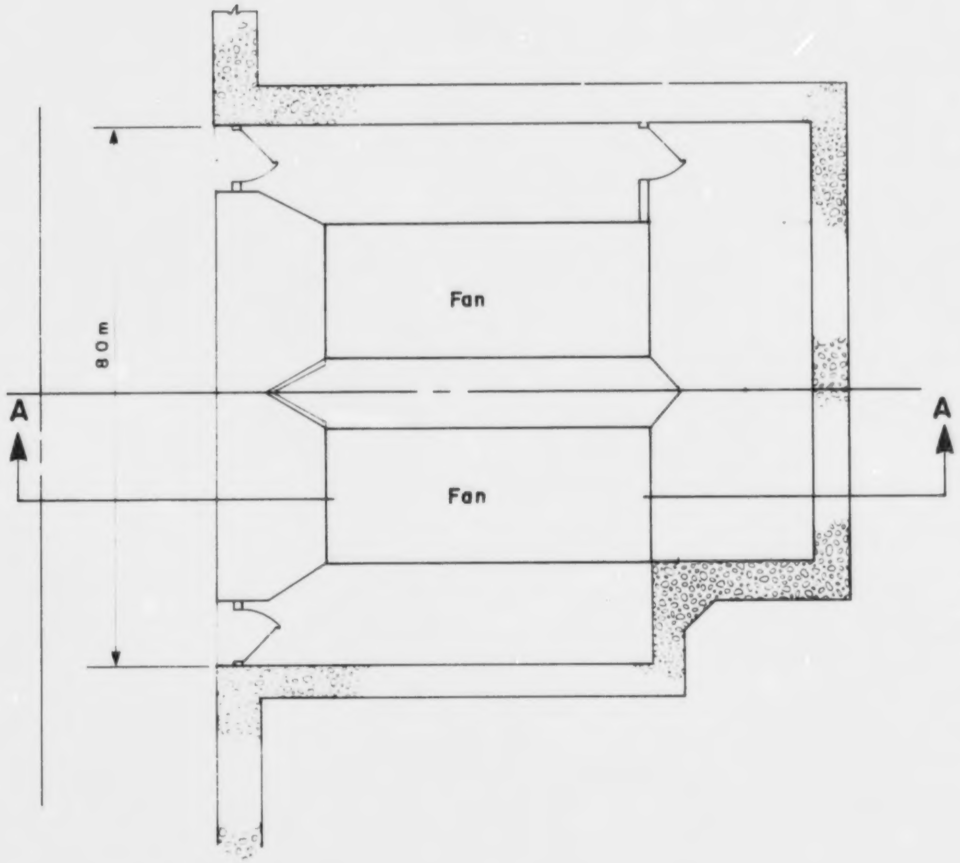
**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN**

## UNDERGROUND OPTIONS TYPICAL LOCATIONS FOR VENTILATION STRUCTURES ALBERT/QUEEN ALIGNMENT

**EXHIBIT 9.3**


229,000 cfm
108 m³/s
10 m
2.0m N.T.S.
2300 fpm
11 m/s
2.5 m ABOVE GRADE
SHAFT
2.0m x 5.0m
N.T.S.
MOTORIZED LOUVRE
3.0 m
2-AXIAL FLOW FANS AND SILENCERS
115,000 cfm (each)
54 m³/s

SECTION A-A


Fan
80m
A
A
Fan

TYPICAL FAN SHAFT

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
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**DELCAN**

**UNDERGROUND OPTIONS**
**TYPICAL**
**VENTILATION STRUCTURES**

- Selection of bus engines and the fuel to be used in the Transitway to determine the levels of pollutants in their exhaust.
- Refinement of primary ventilation system design using sophisticated computer based analysis models to match volumes to normal and emergency requirements.
- Investigation of the potential fire load of the buses to be operated in the Transitway.

## 9.7 Vehicle/Fuel Technology

### 9.7.1 Introduction

The diesel engine, articulated bus is a highly efficient and rugged vehicle capable of carrying a large number of passengers at a low cost in terms of labour, fuel and maintenance. However, the engine exhaust of the present vehicles contains relatively high concentration of nitrous oxides, as well as suspended carbon particles in the form of smoke. These pollutants are an environmental problem for an enclosed Transitway and are undesirable on confined surface streets. The noise levels generated by diesel engines, especially when accelerating, are relatively high.

This section examines the alternative vehicle engine and fuel technologies which could be adopted to overcome these problems.

### 9.7.2 Existing Technology

OC Transpo is currently operating 164 articulated buses, equipped with a mix of Cummins and GM diesel engines. These vehicles, while of the latest design, produce nitrous oxides, smoke and noise. In the period after 1994, new engines and exhaust systems will be in production that will have significantly reduced levels of pollutants in the engine exhaust as indicated in Table 9.1. Engine modifications are to be staged with some improvement expected by 1991. This is a result of mandatory regulations that have been introduced by the Environmental Protection Agency (EPA) in the U.S.A. These reduced levels will be achieved by the use of better engine controls, catalytic converters and exhaust filters. This equipment will raise the cost of buses and require increased maintenance.

At the present time, the Ministry of Transportation, Ontario, (MTO), will fund the replacement of transit buses at approximately 17 to 18 years of life. This rule will result in some of the present bus models remaining in operation perhaps until 2007. During that period, major engine rebuilding will be required at four or five year intervals. At those times it may be possible to retrofit the engines with pollution control devices and achieve improved pollutant levels in the exhaust. However, the current articulated buses can be used in other surface operations. The Transitway Fleet is expected to be acquired in the mid 1990's as part of the normal bus acquisition program.

The ventilation system must be designed to handle the heat and smoke (fireload of a bus) generated by a fire in the tunnel, even though this is an unlikely occurrance. The system will, therefore, have sufficient capacity to handle the exhaust discharge of even the present diesel buses while maintaining safe conditions for passengers and staff using the system. However, operating costs will be relatively high since the ventilation system will have to circulate large quantities of air, for a longer period, during normal peak period operation. The introduction of buses with improved exhaust characteristics will allow the normal, peak period air circulation to be significantly reduced from emergency capacity levels with a consequent saving in power cost.

### 9.7.3 Alternative Fuels

OC Transpo has been operating 10 standard buses equipped with propane-fuelled engines under a test program sponsored by MTO. These tests have shown up some problems in maintaining engine carburetors and spark ignition systems at efficient operating levels. This experiment is now complete.

The Hamilton Street Railway concurrently operated a small fleet of compressed natural gas (CNG) buses with some success, although operating range was limited.

The Toronto Transit Commission has placed an order for CNG fuelled buses that could eventually total up to 125 vehicles to replace some of the existing fleet of trolley buses. Fuel tanks may be located on the roof in order to secure sufficient tankage to allow a good operational range. The MTO is conducting research on this aspect of fuel tank location and vehicle stability. The choice of natural gas-fuelled buses has been dictated in part by the need to limit exhaust pollutants on heavily built-up city streets.

Vienna, Austria has recently made a decision to convert their entire bus system to propane fuel as the existing diesel units are retired. They are currently operating 450 propane buses. The decision was based on a desire to reduce air pollution on the Vienna streets.

In the United States, there has been a move towards methanol as a substitute for diesel fuel. This fuel produces an exhaust with reduced pollutants, particularly hydrocarbons and smoke. The disadvantages of methanol are high fuel cost, limited availability and the introduction of aldehydes in the exhaust. Since aldehydes are in themselves a noxious material it is unlikely that methanol would be suitable for underground use.

Compressed Natural Gas (CNG) has advantages for use in underground applications. They include:

- low levels of pollutants, particularly smoke in the exhaust;
- quiet operation;
- low cost;
- good availability of fuel supplies;
- comparable engine performance;
- extended engine life.

The disadvantages are:

- current low availability of engines for CNG, but this is changing as interest grows;
- higher vehicle costs due to special engine modifications and high pressure fuel tanks;
- need for spark ignition;
- need for carburetor air/fuel mixing;
- large fuel tankage to obtain required range;
- relatively (compared to diesel) long refuelling time.

There have been fears expressed that CNG use would be a hazard in tunnel operations. However, this is not borne out by investigation which shows natural gas to be the safest fuel. This is a function of high strength tanks designed to contain compressed gas which are able to withstand severe accidents without losing their contents. The gas in itself is not explosive and requires a large quantity of oxygen to burn. In the case of leakage, natural gas does not "puddle" in low points as is the case with propane. Natural gas is lighter than air and would be swept out by the tunnel ventilation system.

**Exhibit 9.4** illustrates some important recent findings of an MTO research project. Several alternative fuels are compared to the current (1988) diesel fuel to show what the incremental cost in $/100 km would be. The '0' reference line is 1988 diesel, and the graph shows that the 1991 diesel will cost about $4/100 km more than the 1988 diesel. This would be due to the modifications required to obtain the 1991 EPA standards for exhaust pollutants. Propane would cost about $2/100 km less, and natural gas vehicles (NGV) slightly less than that. Methanol and trolley powered vehicles are much more expensive. The two bars for each fuel show the effect of taxes. NGV appear to have some potential benefits as a fuel, especially for a large operation such as a transit fleet. The absolute difference between the 1991 diesel and the NGV would be about $6/100 km, which could be a very substantial amount.

MTO is also researching ways to store the fuel at lower pressures and still obtain good storage volumes through special absorbtion materials. Research is also under way on methods to improve fueling time.

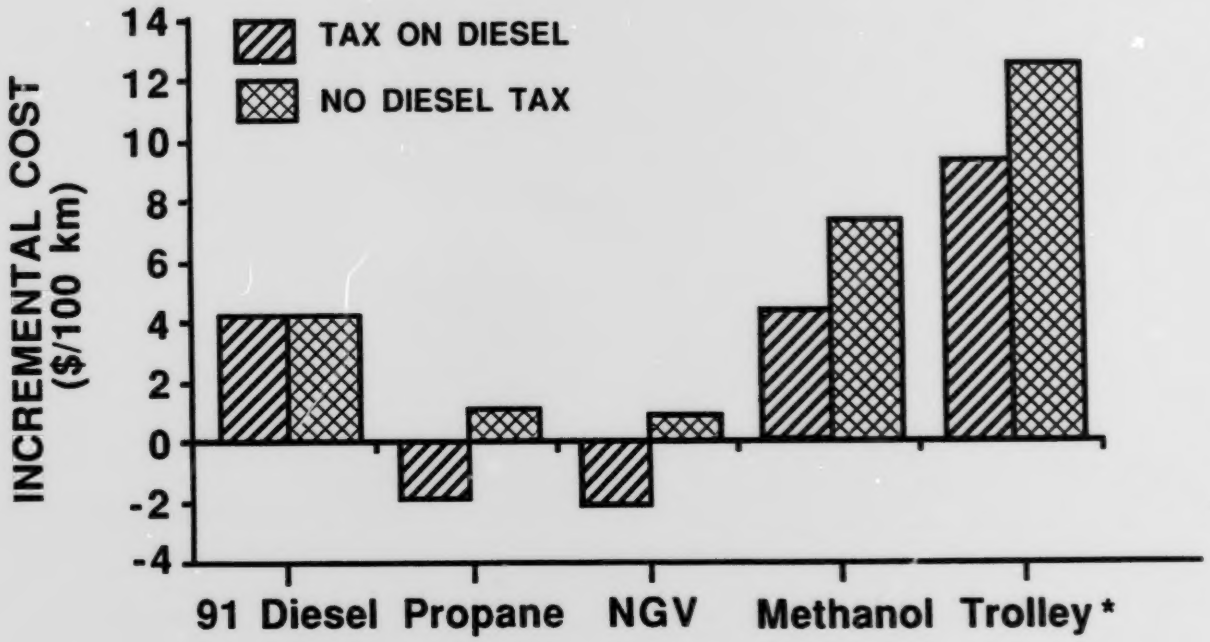
There are other combinations of fuel/power that are currently in limited use or in the research stages. These include trolley-diesel (Seattle), battery-diesel (research) and CNG-diesel. OC Transpo's current fleet of articulated buses will meet Ottawa-Carleton's needs until the early 1990's. Between now and then, it will be important to complete the fleet/fuel studies and decide upon a power plant and fuel for buses that will be used in the Transitway. As stated before, the ventilation system will be designed with a capacity dictated by a fire safety standard, and it would be more than adequate to accommodate these proposed vehicle/fuel alternatives, and even accommodate a fleet which contains a low volume of diesels, particularly diesels meeting the 1994 EPA standards.

It is recommended that the use of compressed natural gas (CNG) for powering future buses be investigated along with other fuel/vehicle combinations, with the objective of reducing the pollutants discharged in the tunnel. This will reduce the normal level of ventilation required with consequent savings in cost of fan operation and reduced noise levels. The size of the ventilation system will still be determined by the need to remove heat and smoke produced by a fire emergency. Among the areas to be investigated in subsequent studies are:

- engine performance in operations and maintenance;
- operating range;
- operating costs;
- refuelling systems;
- vehicle costs.

**EXHIBIT 9.4**

**Life-Cycle Cost Increment**
**Relative to 1988 Diesel**



* Excludes new infrastructure for trolley

# CHAPTER 10

# 10.0 IMPACTS ON CENTRAL AREA REAL ESTATE

## 10.1 Introduction

The introduction of a grade separated transitway through the Central Area will have a significant impact on the everyday life in the downtown. Retail, business and commercial activity will be affected and the transportation system - pedestrian, auto, truck and transit - will be affected in a positive or negative way depending upon the option selected and how successfully it is introduced and integrated into the fabric of the City. There will obviously be a short term construction impact. The extent to which the construction impact can be minimized will be an important feature of any particular option. In addition, depending upon the option selected, the long term impact will be important, both for the total Central Area and for the specific corridor.

This chapter sets out the findings with respect to the potential impact of the grade separated options on the real estate and business communities in the Central Area. The primary focus is on the area from Bronson to Elgin.

## 10.2 Real Estate Owner Impacts

### 10.2.1 Identification of Major Factors

An analysis of the impact on real estate values resulting from the construction of an elevated, cut-and-cover or tunnelled rapid transit corridor must take into account the fundamental influences on value that will occur during the construction period as well as over the long-term post-construction period. Those factors that increase or decrease the demand for property, improved or otherwise, will affect the yield a property can earn or, in the case of say a park, the amount it will be used. The following specific items are some of many which have been considered in this review of possible impacts of the different options:

- Existing Development, Quality and Age;
- Transition and Trend;
- Undeveloped Parcels;
- Permitted Uses;
- Utilities;
- Landscaping features;
- Accessibility;
- Convenience;
- Before and After Highest and Best Use;
- Construction features of the Transitway;
- Special Equipment;
- Quality;
- Maintenance effects (snow removal, exterior maintenance, structural maintenance);
- Physical Dimensions Relative to the Available Space.

Some of the above factors have been described earlier in the context of each of the options. The following analysis refers to some of these factors again, but from the Real Estate Impact viewpoint. In general terms however, the streets directly affected are for the most part already improved with buildings which have considerable remaining economic life. This important factor removes most of the capability to adapt easily to some aspects of the proposals, the integration of underground stations with the basements of existing buildings is an example. Other items such as maintenance have been considered only as they affect the aesthetic value of an area or the resulting economic loss of employment time or the delays created by snow removal requirements during or after the inevitable winter storms that occur every year in Ottawa.

It is fundamentally accepted that all three options, elevated, cut-and-cover and tunnel, will benefit the Central Core as a whole. The easier access to and egress from the core will be an economic benefit to the overall, not withstanding that one or other option might well depreciate some specific portions of downtown development in the specific corridor of the facility.

In Tables 10.1 to 10.4, the relevant factors are divided into four categories and a summary of the impacts presented for each option:

(A) Construction Disturbance
(B) Post-Construction Disturbance
(C) Economic Advantages or Gains after Construction
(D) Economic Disadvantages or Losses after Construction

### 10.2.2 Access Points

The construction of a network of underground or overhead access points to the stations provides cover for users during Ottawa's inclement weather periods. Strategically positioned entrances should increase pedestrian traffic to such areas as the Sparks Street Mall, the Rideau Centre and other Centre Core attractions. A logically located transitway can easily service the core being only 5 blocks wide for all intents and purposes. The tunnel option provides the most flexibility in this regard as it can be located with little damage to the existing surface improvements.

The overhead concept would require that an inter-building, above-ground complex be created in order to have the same effect as a well planned, underground access system. This would take considerable time and could prove to be quite inflexible. Conversely, the underground could be connected to the shopping concourse at Place de Ville, the Congress Centre and the Rideau Centre, all below grade. An access point on the Canlands, would be desirable for that facility and would put a transit passengers only one block south of the centre point of the Sparks Street Mall and only two blocks from Parliament Hill.

### 10.2.3 Station Locations

Station locations can be adequately located in all of these proposals although, again, the tunnel should provide the best all around facilities. Stations constructed for an underground transitway system permit relatively flexible planning without restricting at-grade or above-ground level utility. Indeed a multi-use development which includes an underground station should have additional economic value. There are vacant parcels available for this purpose at present which should be protected if the underground or cut-and-cover systems are to be used:

(a) The former Carson factory site, mid-block between Metcalfe Street and Elgin Street running from Albert Street south to Slater Street, now vacant.

(b) The Tilden lot, north side of Slater Street east of Bank Street (capable of being extended to Albert Street).

(c) The Campeau parcel, east Kent Street, between Queen and Albert Streets.

(d) The west side of Lyon Street between Queen and Albert Streets, opposite the Skyline Hotel, and between Albert and Slater Streets.

### 10.2.4 Aesthetics and Preservation of Open Spaces

The Cut-and-Cover and Tunnel options have little or no effect on the existing streetscape of the Central Core, neither do they affect in any substantial way the open spaces, passive or recreational. The overhead option offends the streetscape greatly and reduces the amount of land currently available for park purposes.

An overhead structure running the length of Slater Street, over Elgin Street and to the north of the Park, over the Canal, through the Department of National Defence Building, and curving back to grade in front of Ottawa University, is undesirable from an aesthetic point of view. Its proximity to existing buildings depreciates their value and affects the environment. A modern comparison could be the Gardner expressway along the Harbour Front in Toronto. The "EL" in Chicago or the overhead expressways in Manhattan, as necessary as they might well be, are comparable examples of older construction which have physically depreciated over time. These facilities are not located in the heart of the city, nor as close to existing buildings as would be the case in Ottawa.

The Vancouver Sky Train is elevated in open space outside of the core, but is underground through the core. The overhead portion has incorporated gardens and theme plazas into its plan which mitigates the impact of the structure. This treatment would not be possible in the Central Area of Ottawa. The underground portion, 2.4 kilometres long, runs from the waterfront to B.C. Place stadium. The downtown is therefore not cluttered with support columns and girders, nor do they have narrow roadways underneath such a superstructure. The effect at grade of an overhead within the constraints of a narrow street would be to create a subterranean atmosphere.

The Central Area is the centre piece of the Nation's Capital city. It should be treated as a showcase and be perceived as such by Canadians and visitors alike. A streetscape impeded by an overhead structure would have a general depreciating effect on this perception and would lower values within part of the core. The vistas along any of the north/south streets would be impeded. Proposed elevated station locations would spread into the cross streets and enlarge the affected areas adjacent thereto.

### 10.2.5 Maintenance, Physical Depreciation and Functional Depreciation Factors

(a) Maintenance: Snow removal may be a problem for the overhead scenario even though it is planned to heat the running paths. A major snow storm could impede the use of the corridor. Employee time loss for late opening hours or early closing hours would be substantial, as it is now, if transit service was severely disrupted. Bus traffic could be rerouted to other streets during such times and such a procedure would probably be compared to that of current experience during major snow falls. The underground system would be a significant improvement over existing conditions and hence office shut-downs should be less frequent.

(b) Physical Depreciation: This is likely to occur at a faster rate for exposed elevated structures than for the underground options. This item includes the requirement for a maintenance program not unlike that experienced with bridges. The need for cosmetic attention would be ongoing, the lack of which would be a depreciating economic factor to surrounding property. There may be a considerable period of time before refurbishing takes place when the superstructure will look its worst.

An underground system will have the same maintenance requirements within its stations but the tunnel itself should require less. The streetscape is not affected when the tunnel is in need of refurbishing and routine care and cleaning.

(c) Functional Depreciation: The columns which carry the superstructure of the elevated option are to be located every 30 metres and set approximately 1.5 meters from the property lines. This will result in restrictions on pedestrian movements around the columns. Further, as the span is a different length than the width of the registered lot lines (20 m), the columns may, in some cases, be located in awkward spots in front of existing buildings. This can be improved by matching span length with lot line width but would result in structural problems.

The overhead transit system will reduce the utility of the street for traffic movement by reducing the number of lanes from four to three.

### 10.2.6 Estimates of Economic Gains or Losses

a) Cut-and-Cover Construction

Major disruption for the construction period will occur with either the cut-and-cover or elevated transit options, which will take a minimum of three years to complete. Although using the cut-and-cover method the major interference with automobile, transit, trucking and pedestrian traffic is limited to the initial cutting and later paving of the street, the disruption is nonetheless considerable. The period of time of intensive ground work required to place the deck will virtually shut down normal access other than pedestrian to stores, businesses and buildings in the sections being worked on. The actual measure of business loss is nearly impossible to realistically estimate before the fact. During similar construction in Seattle, the construction was shut down and the street more or less restored during the busy Christmas period. This portion (Pine Street) of the Seattle project was taken out of service for over a year and only temporary pedestrian ways provided.

b) Elevated Construction

Elevated construction is somewhat similar. The realignment of services, reconstruction of sidewalks, the construction of columns and the installation of the superstructure sections will create an access problem. The columns can be set with only local interference and there is limited hauling of excavated material required. However, it is nearly impossible to accurately estimate the extent of the economic loss during this period but there is no doubt that it will occur.

c) Tunnel Construction

The tunnelling technique should have a limited effect on business. Hauling of construction debris and material is done from either end of the tunnel, out of direct street disturbance at the Bronson end and from a fairly open and flexible point on Waller Street at the easterly end if required. There will be disruption where the tunnel section transitions to the existing Transitway, particularly at the east end.

d) Station Construction

Station access points on street intersections will be disruptive but on a localized basis. The cross street stations proposed for the elevated will considerably affect north/south traffic at these points. The cut-and-cover option across intersections will also be disruptive. The construction of off-street stations with either the tunnel or cut-and-cover options should have similar impacts to that of the construction of a new building, with hoarding and hauling required for a foundation excavation, and thus minimal disruption to normal street activities.

e) Post-Construction Period

The entire core should, on average, gain economically from the provision of a transit corridor whichever method is used.

None or limited long-term streetscape damage occurs from either the cut-and-cover or the tunnel option save and except for ventilating structures and street entrances to the transitway stations.

Considerable damage would occur to those streets which would carry the elevated system. Class "A" buildings would become "B" or even "C" class buildings. A depreciation in value of 15% to 30% of market rental achievement should be expected. Their value could be expected to decline a similar amount.

It should be noted that over the past 10 years newly constructed buildings have fiercely competed for tenants. Rental incentive plans have been quite incredible; free rental periods, inflated tenant improvement allowances, cash bonuses, etc. Some tenants have been paid cash bonuses just to remain in tenance at renewal time. It is possible that the benefits gained by having easier access to and egress from the core will tend to normalize the office market thus increasing the demand for space sufficiently to remove these bonus programs. It should create good income streams and result in normal vacancy rates and fair returns to the investors.

Conversely, buildings along the corridor of the overhead option will severely depreciate on the ground level and to six floors up. Corner buildings which have entrances on cross streets that are unaffected by stations will suffer the least with little or no effect on the higher floors apart from having its address and flankage adjacent to the impeded streetscape. The abutting flankage will be greatly affected.

The ground floors of buildings adjacent to an elevated transitway could suffer a depreciation of rental value by as much as 50 percent. The canopy-like superstructure will create an almost subterranean atmosphere at grade and for the first two floors. The second and third floors, generally office, could well experience the same depreciating effect, i.e. up to 50% of present value. The fourth through sixth floors, slightly above the structure, will have more light but will be subject to the noise and disturbance from moving vehicles (and pedestrians at station platforms) in front of their street side windows. Private offices are normally located along the glazed portions of office buildings and enclosed to permit concentration and an undisturbed work atmosphere. The income stream earned from these locations will also depreciate but to a lesser degree, probably 25% to 30% for directly affected areas. An office building fronting onto an overhead would suffer direct overall value loss by having its address depreciated.

Apartments and hotels would be more severely damaged. Night-time access to and egress from such buildings in a fairly confined, somewhat enclosed atmosphere could be frightening to many. They would simply avoid the experience, real or imagined. Depreciation in this area is impossible to estimate before the fact.

Real Property taxes are calculated on assessments which are directly related to Market Value. Any depreciation in Market Value directly affects the amount of taxes received by the Municipality. The Ontario Municipal Board recently reduced a homeowner's assessment by 5% just because of a neighbourhood mailbox stand located adjacent to the homeowner's frontage.

f) Estimated Range of Direct Annual Tax Loss

The amount of damage is most difficult to determine and relates to major, severe and/or moderate damage. The range can only be expressed as an estimated percentage for each respective category; major by as much as 30±%, moderate 10±%. The range of estimated Annual Tax loss could be between two and four million dollars.

### 10.3 Summary and Conclusions

- An overall gain in realty value should result from a grade separated transit corridor being centrally located within the Core. There is some doubt as to the extent of this overall gain for the elevated option.

- An underground system, particularly the tunnel option, will preserve the streetscape and create the greatest overall economic gain.

- The tunnel option offers the opportunity for the development of well-located off-street station connections which if carefully planned, would permit desirable integrated office and retail accommodation. This could be premium space.

. The cut-and-cover option presents many of the long term benefits of the tunnel option, but has a negative impact during the construction which is expected to be at least three years in duration

. During construction, the impact of the surface disruption will be felt in many ways including: less attractive pedestrian access to business as along the construction route; reduced sales by some establishments, particularly convenience stores dependent upon walk-in traffic: Noise and dirt associated with construction activity will also reduce the attractiveness of the area.

. The elevated option will result in depressed property value and reduced development potential along its route. This will likely result in a permanent tax loss because of the impact of the elevated structure on adjacent property.

. A well designed network of access points to the Transitway stations would create an effective service for all transit users within the core and assist in the dispersal of transit passengers over a larger section of the Central area.

. The Nation's Capital is a show place for Canadians and as such should reflect our pride. The Transitway should be designed to high standards and should reflect an overall perception that Parliament Hill and the Central Core are "people places", alive and attractive.

## TABLE 10.1

| .ITEM | OPTIONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| LOCATION<br>A. CONSTRUCTION DISTURBANCE<br>General | (Albert St., Queen St. or Both) or Albert/Queen<br>- Half block at a time<br>- Useable once decked (Decking 2 to 3+ weeks per section)<br>- 2 to 3 weeks to finish and pave<br>- Disruption - 3 years<br>- Stations off-site or under street<br>- Construction dirt and grime<br>- Noise is a problem | - (Albert, Queen, Slater Sts. or Albert/Slater).<br>- Not disruptive.<br>- Stations off-site or under streets.<br>- virtually no dirt or grime (station hoarding). | - (Slater St.).<br>- 4 to 5 months per block (3 months for piers and foundations for superstructure).<br>- Shut-down 2 months per block.<br>- Stations over streets at intersections.<br>- Construction dirt and grime.<br>- Noise is a problem |
| 1. Trucks: Removal of excavation and return of new materials or structural components | - At either end of each half-block during construction of each block<br>- Stations same as a building being constructed to ground level either off street or under street. | - Only at entrances to tunnel at east and west ends.<br>- Stations same as a building being constructed to ground level either off street or under street. | - During relocation of utilities and re-building of streets and widewalks, construction of foundations and piers and pre-cast overhead bridging.<br>- Cross streets compound disruption during station construction. |
| 2. Automobile Parking | - Disruption at all lots and garages while being cut (before cover) and during paving. 6 weeks per ½ block. | - Disrupted at station sites. | - Disruption during service relocation, streets and sidewalks and for piers, also during bridging |
| 3. Automobile Traffic | - Disruption during 4-6 weeks of cut and cover, etc.<br>- Half-use and then full-use roads. | - Minor disruption at station sites and slightly at access entrances.<br>- Full use of roads. | - No traffic during bridging etc. (2 months).<br>- Disruption during utilities relocation, foundation and pier construction. |
| 4. Off-street Loading and Building Services | - Severely disrupted on ½ block sides during cut; moderately during paving. | - Virtually no disruption except at stations and none if off street. | - Disruption during service relocation and bridging, etc. |
| 5. Pedestrian Access | - Severely disrupted during cutting and covering. 4 to 6 weeks. | - Little or no disruption. | - Severe disruption during utility relocation and bridging (5 months). |
| 6. Transit Service | - Very serious disruption to surface routes with little opportunity to avoid construction areas. | - Minimum disruption. | - Very serious disruption to surface routes with little opportunity to avoid construction areas. |
| 7. Economic Damage during Construction Stage (No pain - no gain)<br>(a) Retail<br>(b) Office<br>(c) Residential<br>(d) Hotel<br>(e) Transit Operating Cost | (a) Major during cut and cover, severe but less during underground work.<br>(b) Serious during cut and cover, inconvenient during underground work, and noise.<br>(c) Same as (a) and noise.<br>(d) Same as (a) and noise.<br>(e) Expect extra operating cost. | (a) Major at stations and entrances unless off site.<br>(b) Little or none.<br>(c) Little or none.<br>(d) Little or none.<br>(e) Little or no extra cost. | (a) Major during service relocation and bridging, etc.<br>(b) Major as in (a).<br>(c) Major as in (a).<br>(d) Major as in (a).<br>(e) Extra operating costs. |

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EVALUATION ANALYSIS
REAL ESTATE
AND OWNER IMPACTS

## TABLE 10.2

| ITEM | OPTIONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| 8. Relocation of Utilities | - 2 to 3 weeks during the cutting and covering period. Completed under decking. Some utilities done in previous year with disruption. | - Little disruption, only at access points. | - Utilities are preinstalled requiring 3 months disruption per block. |
| B. POST-CONSTRUCTION DISTURBANCE<br>1. Retail | Nil | Nil | Proximity to buildings impedes light to lower 3 floors and creates a subterranean atmosphere. This will reduce location appeal to purchasers. |
| 2. Office | Nil | Nil | (a) Noise disturbance will be on going and will affect up to 4 to 5 levels of office space.<br>(b) Proximity to buildings will have a major aesthetic affect on office levels 2 to 4 inc., depreciating their value. |
| 3. Hotels/Apartments | Nil | Nil | Same as 2(a) and (b) above.<br>- The effect will have greater depreciation on rental value of hotel rooms adjacent to superstructure and to value of condominium units along side same, Floors 1 to 4 or 5. |
| 4. Parks, Intersections, etc. | Nil | Nil | Change character of adjacent properties and their values either rental or market.<br>- Loss of park space, i.e. south of Technical H.S. a depreciating factor. |
| C. ECONOMIC ADVANTAGES OR GAINS AFTER CONSTRUCTION<br>1. Traffic: (a) Pedestrian | i) Ease of access to Central Core will entice people to use the existing variety of commercial and public attractions.<br>ii) Significant increase in pedestrian traffic.<br>iii) Underground property ammenities possible but limited to buildings adjacent to transitway or their access tunnels. | i) Same as cut and cover option.<br>ii) Significant increase in pedestrian traffic.<br>iii) Same as cut and cover option. | i) This option will result in a less attractive Slater Street due to loss of sun and obstructions caused by columns along the sidewalk.<br>ii) Significant increase in pedestrian traffic.<br>iii) Blends in well with the possible plus 15' overhead inter-building connection concept. The concept would see covered interblock connections generally throughout the core. |

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EVALUATION ANALYSIS
REAL ESTATE
AND OWNER IMPACTS

**TABLE 10.3**

| ITEM | OPTIONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| (b) Automobile | Some automobile users will switch to transit. However, automobile use relates to ease of parking and ease of movement. This is helped by not having buses on street. Increased on-street parking a probability. | Some automobile users will switch to transit. However, automobile use relates to ease of parking and ease of movement. This is helped by not having buses on street. Increased on-street parking a probability. | i) Same and cut and cover option save for any super-structure impediments which might occur.<br>ii) Lost lane of traffic on Slater Street. |
| 2. Rental Space<br>(a) Retail | i) Marginal additional space at or in stations.<br>ii) Additional traffic to core and ease of exit from core may keep people there longer.<br>iii) More people, more sales, higher rents, more value. | i) Marginal additional space at or in stations.<br>ii) Additional traffic to core and ease of exit from core may keep people there longer.<br>iii) More people, more sales, higher rents, more value. | i) No retail space<br>ii) Additional traffic to core and ease of exit from core may keep people there longer.<br>iii) More people, more sales, higher rents, more value. |
| (b) Offices | Ease of access will encourage companies to locate and/or remain in core. Office personnel like the core atmosphere once they reach their destination.<br>- Should increase demand. | Ease of access will encourage companies to locate and/or remain in core. Office personnel like the core atmosphere once they reach their destination.<br>- Should increase demand. | Ease of access will encourage companies to locate and/or remain in core. Office personnel like the core atmosphere once they reach their destination.<br>- Should increase demand. |
| (c) Apartments | Ease of access means ease of egress. Apartment dwellers in or close to core can work and shop in core.<br>- Should increase demand. | Ease of access means ease of egress. Apartment dwellers in or close to core can work and shop in core.<br>- Should increase demand. | Ease of access means ease of egress. Apartment dwellers in or close to core can work and shop in core.<br>- Should increase demand.<br>- Will reduce attractiveness along route. |
| (d) Hotels | Helpful to their retail stores, restaurants and entertainment facilities. No real gain for room occupancy. | Helpful to their retail stores, restaurants and entertainment facilities. No real gain for room occupancy. | Helpful to their retail stores, restaurants and entertainment facilities. No real gain for room occupancy.<br>- Will reduce attractiveness along route. |
| 3. Rideau Centre/Sparks St. Mall Parliament Hill & N.A.C. | - A Queen Street/Albert Street one way concept creates a "dead centre" of the core alignment. Underground access points would fan out to easily service all of the core.<br>- Direct link to Rideau Centre.<br>- Acceptably close to Sparks Street Mall and Parliament Hill. | A mid-block tunnel, Albert/Queen or Albert/Slater, provides a flexible alignment.<br>- Direct link to Rideau Centre.<br>- One block further removed from Sparks Street Mall and Parliament Hill. | Less flexible than the cut and cover option but certainly flexible from access point of view.<br>- Rideau Centre access from south side of McKenzie Bridge - less desirable.<br>- N.A.C., Parliament Hill and Sparks Street Mall acceptably close. Plus 15 concept would provide good cover within core. |
| 4. Station Locations | Could utilize off-street vacant sites so that vacant parcels can be utilized and designed to take advantage of unrestricted planning, still maintaining full air-right utility. | Permits mid-block or understreet stations, very flexible concepts allowed. | Stations could be part of Plus 15. |

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EVALUATION ANALYSIS
REAL ESTATE
AND OWNER IMPACTS

## TABLE 10.4

| ITEM | OPTIONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| D. ECONOMIC DISADVANTAGES OR DAMAGES AFTER CONSTRUCTION | | | |
| 1. Retail | Nil | Nil | Ground floor retail under overhead route and station platforms will probably sustain significant damage.<br>- Loss of unimpeded light and presence of structural members depreciatory.<br>- Rideau Centre access by crossing McKenzie King Bridge |
| 2. Offices | Nil | Nil | - Lower floors probably to fifth level severely damaged by noise, loss of light, pedestrian walkways opposite windows at station location, etc. Note: Most often, offices of those who require privacy, etc. are in windowed side of buildings, and these will be most affected. Senior personnel would veto location.<br>- Extensive rental reduction as enticement could attract some tenants. |
| 3. Hotels | Nil | Nil | Fly-over at Elgin Street depreciating to Lord Elgin (loss of view and direct presence on Ceremonial Route to Hill). Bridge could physically segregate Elgin.<br>Damage extensive.<br>Howard Johnson's first 4 or 5 levels significantly affected along frontage.<br>Damage extensive.<br>- If Albert Street chosen damages more severe. (3 Hotels and Elgin Street Bridge). |
| 4. Residential Apartments/Condominiums | Nil | Nil | - Disrupted view and light.<br>- Appreciable increase in noise and dirt to first 4 or 5 floors.<br>- Loss of parks and open space for leisure. |
| 5. Open Space | Nil | Nil | - Fly-over at Elgin affects Ceremonial Route view.<br>- Extra width at McKenzie Bridge over existing park and canal takes away space and depreciates aesthetics of area.<br>- Recreation Park for Ottawa Technical H.S. and neighbourhood severely affected. |

**REGIONAL MUNICIPALITY OF OTTAWA - CARLETON**
**CENTRAL AREA TRANSITWAY**
**GRADE - SEPARATION FEASIBILITY STUDY**
**DELCAN / A.H. FITZSIMMONS**

**EVALUATION ANALYSIS**
**REAL ESTATE**
**AND OWNER IMPACTS**

# CHAPTER 11

# 11.0 RETAIL AND COMMERCIAL IMPACT

## 11.1 Introduction

This chapter presents the results of an investigation by John Williams and Assoc. of the possible impacts of a grade separated transitway on retail and commercial business in the Central Area. Data were collected from the City of Ottawa, R.M.O.C., and from various reports made available to the study team. In addition, interviews were made with many business people throughout the Central Area. It is very difficult to quantify these potential impacts. The experience of Toronto Transit Commission was also reviewed. The retail and business impacts in this analysis are important not so much with respect to absolute numbers but mainly in how the possible impacts of the different options affect the relative position of one option versus the others. In this way, a comparative evaluation of the options was possible.

## 11.2 Study Background

### 11.2.1 Boundaries

The boundaries of the study area for the retail impact investigations were Elgin Street, Wellington Street, Bronson Avenue and Gloucester Street.

Estimations of the impact of the options on retail sales also included Rideau Centre but areas around Rideau Centre were not included in the study of commercial impact.

### 11.2.2 Macro Economic Evaluation

In addition to providing new services and maintaining service quality, capital expenditures on a grade separated transitway will have secondary effects in the economy; namely the effect on income, tax revenues, etc. It is important to note that transit capital investments not only benefit industries supplying materials and services directly to the transit industry, but also generate substantial revenues in many other business sectors within the economy.

In order to measure the impact of capital spending in the transportation industry, the American Public Transit Association (APTA) developed a model. The basic method used was an input-output model provided by the U.S. Department of Commerce, Bureau of Economic Analysis, which contains information on 39 major categories of impacted industries. The model is commonly known as RIIMS II. It estimates the total increases in sales/income as a result of a dollar increase in the purchase of goods and services.

A comparable Canadian model was not available. While there is a Transportation Impact Model (TRIM) developed through the Institute for Energy Studies at McMaster University, Hamilton, Ontario, it was not directly applicable to this situation as it was designed to be applied to highway developments. However, the finding in relation to the multiplier effect for gross sales (3.08) is very similar to the output provided by the RIIMS II model.

### 11.2.3 Micro Evaluation Analyses

An evaluation model was developed to measure the effect on commercial and retail facilities of six grade separated transit alignment options. The model assumed that a grade separated transit option, by nature of its permanence, will influence the development of commercial and retail facilities in the study area. This assumption was verified during interviews with key Ottawa developers.

The major benefit provided by the transit system is the delivery of employees to their places of work in an efficient manner. Improvements to the transit system make the central core more attractive to businesses looking for office space. This stimulates office development, and indirectly retail sales, as much of the retail sales in this area is derived from the office workers.

The key measurement chosen for this study was the change that could be expected in retail sales. The retail sales in the area of study are influenced by the alignment chosen for the transit system. Changes in retail sales will be affected by the changes in pedestrian and vehicular traffic patterns, the overall increase in transit ridership and the increase in office employment in the downtown. The change in retail sales results in direct changes in expenditures on wages to retail workers.

It is assumed that the transit system will develop a small amount of passenger convenience related retail space in the grade separated stations. The rental of this space will generate income for O.C. Transpo.

There will also be changes to assessed value of buildings along each corridor. These changes could be positive or negative depending upon the option. An estimate of the magnitude of these changes was made both in this analysis and in the previous chapter which discussed the real estate impact.

### 11.3 Baseline Information

In order to estimate the economic benefits of a grade separated transitway, baseline information on retail sales was developed. The baseline information used 1987 values and forecasts were made based on current trends. These trend forecasts are the values which could be expected if no changes were made to the current transit system.

A complete inventory of the retail space in the study area was conducted. Retail sales were calculated by applying the sales per square foot by merchandise category which are considered industry averages. Retail sales were projected at a rate of 1.8%. This is the level of growth estimated in the study Retail Facilities in the R.M.O.C. by Larry Smith and Associates.

Total retail wages were calculated to be 15% of retail sales. This is an industry average which comes from the experience of John C. Williams Consultants Ltd. in the retail field.

Estimates were also made of potential OC Transpo income generated from the rental of retail space. The baseline measurement is zero because the transit system currently does not lease out retail space in the study area. It is assumed that O.C. Transpo would not develop retail space except in stations in a grade separated system. Even then, the amount of retail space is small and related to passenger convenience.

### 11.4 Options Evaluated

The options which were evaluated by the macro economic model (modified RIIMS) were the cut-and-cover, the elevator, and the tunnel.

The options which were evaluated by the micro economic model of retail sales were:

| CONSTRUCTION METHOD | ALIGNMENT |
|---|---|
| Cut-and-Cover | Queen Street<br>Albert Street<br>Albert and Queen (one way pair) |
| Tunnel | Queen Street<br>Albert and Slater (one way pair) |
| Elevated | Slater Street |

In the analysis, the stations were located approximately as follows regardless of alignment:

Rideau Centre
Metcalfe Street
Bank Street
Lyon Street

It was estimated that the stations would accommodate the following net leasable retail space:

| | |
|---|---|
| Rideau, Metcalfe, Lyon Station: | 350 sq. ft. each |
| Bank Street Station: | 710 sq. ft. each |

The only exception to this retail space allocation was the elevated option where it was decided to keep the sizes of the stations to a minimum. It was assumed that there would be no retail space in stations in the elevated option. The optimum leasable area was determined in consultation with TTC using data from the Toronto Transit System. The pedestrian traffic flows in key stations were used to calculate the supportable retail space.

Areas of Impact

In the analysis, it was necessary to identify areas of impact for each option. The areas of impact were established by alignment and construction phase as follows:

Primary Blocks - these blocks receive maximum levels of impact

Secondary Blocks - these blocks are adjacent to primary blocks and can be expected to be impacted by construction to lesser degree than the primary blocks.

The assumptions which were made in determining the areas of impact were:

During Construction

Cut-and-Cover - All blocks on both sides of the alignment are designated as primary blocks since the whole street must be torn up for this construction method.

Tunnel - The blocks where the stations are being constructed are denoted as areas of secondary impact because the level of disruption will be considerably less than for Cut-and-Cover. The retail businesses will have access at all times. Heavy construction equipment and some relocation of utilities, etc., will cause some disruption.

Elevated - The primary area of impact is designated as all blocks on Slater Street because the whole street will be affected by this construction technique.

After Construction

The areas of impact are defined by the alignment rather than the method of construction. The primary blocks are those in which a station can be expected to be located. These blocks will receive the maximum levels of transit passenger flow. Secondary blocks are the blocks immediately adjacent to the primary blocks. They will benefit from the transit passenger flows to a lesser degree than the primary blocks. The final design of the transit passenger access network will influence these findings. A wider network of access points will spread the transit passenger traffic and thus the potential retail sales, over a larger area.

## 11.5 Estimated Impact on Retail Sales of the Different Construction Options and Alignments

### 11.5.1 Macro Economic

Based on the RIIMS II model, the economic impact of capital spending will have a multiplier effect on approximately 3.5 times the construction costs. This benefit would accrue to the total Region and would occur with most capital projects. The benefits are not specific to a transit investment.

### 11.5.2 Micro Economic - Retail Sales Impact

The estimated economic benefits derived from the micro economic model are estimated as the difference between a baseline scenario or current trends with no grade separated system and a scenario which assumes a grade separated system. Table 11.1 presents the results.

## TABLE 11.1

## SUMMARY OF ESTIMATED FINANCIAL IMPACTS AS OF 2001

| | Increase in Annual Retail Sales ($,000,000's) | Increase in Annual Retail Wages ($,000,000's) | Annual Retail Rental Income O.C. Transpo ($,000's) |
|---|---|---|---|
| Cut-and-Cover | | | |
| Queen Street | 12 | 5 | 345 |
| Albert Street | 27 | 7 | 345 |
| Albert/Queen | 14 | 5 | 345 |
| Tunnel | | | |
| Queen Street | 29 | 8 | 345 |
| Albert/Slater | 29 | 8 | 345 |
| Elevated | | | |
| Slater Street | 10 | 1.5 | 0 |

The values shown for retail sales represent the changes in retail sales which would likely result from the alteration of pedestrian traffic patterns caused by the transit system changes. The increases in retail sales will benefit the following groups:

- Existing Retailers

  Stores which already exist will benefit from a more efficient traffic flow and from less congestion on Albert and Slater Streets. More office development will also bring more consumers to these retail outlets.

- New Retailers

  As the retail base expands it will be able to support an increased number of retailers. This will bring more retail choice to the core area.

- Consumers

  A better choice of retail stores and healthier retailers will benefit the consumer by giving them good, convenient shopping alternatives in the downtown.

The changes to retail sales have been estimated using change in pedestrian and vehicular traffic patterns in the core as a key factor. The retail base was divided into the following categories:

| | |
|---|---|
| Convenience | - these are businesses which are most sensitive to changes in traffic and include such operations such as variety stores, smoke shops, personal services (e.g. cleaners), etc. |
| Semi Convenience | - these operations are less traffic dependent than Convenience but still rely on walk-in traffic. Substitutes for this merchandise can be found in other parts of the city. Examples of these kinds of operations include most stores which are a part of a chain, such as apparel, accessories, general merchandise, etc. |
| Destination | - these are one of a kind stores which sell merchandise or have services which are not duplicated in the city. They also tend to sell more expensive merchandise and as a result their customers will make an effort to get to the store or will wait to purchase when it is more convenient.<br>- they include such stores as one of a kind jewellers, specialty piano stores, etc. These operations are the least traffic dependent. |

The categorization of the stores was done during the inventory process. Each store was rated by a qualified staff member from John C. Williams Consultants Ltd. according to guidelines developed from previous experience with retailers and discussions with the Sparks Street merchants.

The changes to traffic patterns have been estimated using projections derived as part of the project. The changes in traffic have two different effects on retail sales which are as follows:

During Construction

The impact of construction will be negative. This results from the disruption of the street from digging as well as the presence of construction vehicles. The negative effects on Convenience, Semi Convenience and Destination retailers were estimated using the experience of the Sparks Street merchants. These business people were interviewed to determine the effects of the reconstruction of Sparks Street on their businesses.

The maximum amount of disruption would be felt if the Cut-and-Cover construction technique was used. The assumption has been made that R.M.O.C. would minimize the negative effects of construction as much as possible through a very comprehensive public information and retail assistance program.

After Construction

The effects of changes in the traffic patterns after construction on Convenience, Semi Convenience and Destination retailers have been estimated using the difference in sales productivity of high traffic vs low traffic shopping malls. This information was taken from the Dollars and Cents of Shopping Centres - The Urban Land Institute, 1987.

The phasing of these effects are as follows:

- Effects on Retail Business During Construction

  The assumption has been made that construction would occur over a three-year period. The maximum negative effects would be in the first year because the maximum disruption occurs during the early stages of construction. The actual year when the greatest negative impact would be felt depends on when streets are torn up in the retail sector.

- Effects on Retail Business After Construction

  The positive impacts of the increases in traffic have been phased in over three years starting the year construction is completed and the facility is in operation. The initial positive impacts would be felt by existing retailers. New retailers would start to enter the market in the second and third years. After three years, the new level of retail sales would be established in the core area. This development phasing schedule is based on the experience of John C. Williams Consultants Ltd. with new shopping developments and rehabilitation of older retail facilities.

  The model assumes a net increase in retail sales in the core area. This increase will come from increased commercial employment in the study area and more efficient traffic flow resulting from the removal of a large number of buses from the roads in the downtown area.

### 11.5.3 Changes in Retail Wages

The changes in retail wages are based on the changes in retail sales. They are calculated as 15% of sales. Retail wages spent by existing businesses would be less than 15% because they could use existing staff to sell at least a portion of the sales increase. New businesses are likely to spend more on wages because they must develop their business.

Another factor which affects the retail wages which must be paid to generate increased sales are the kinds of business which would locate in the area. Restaurants and fast food outlets will spend a higher percentage on wages while operations such as general merchants or hardware stores will spend less.

The retail sales which will accrue to new compared to existing operations and the kinds of new businesses which will locate in the study area cannot be accurately forecasted. An average wage has been chosen to demonstrate the benefits of the change in retail sales.

Retail wages which will be paid to employees working in the O.C. Transpo retail locations has also been added to these figures. This amount is assumed to be the same wage rate as for other retail operations.

This increase in the changes in retail wages will benefit the following groups:

- The Unemployed

  In general, the retail industry employs people who do not need special skills and may be unemployed or be seeking entry level positions.

- City of Ottawa, and Other Municipalities

  Increased opportunities for the unemployed will benefit the municipalities because it means a better life for its citizens and fewer demands on the city's social welfare system.

- O.C. Transpo Income

  The income which is referred to in this part of the model is based on the rental of small retail spaces within the stations. The space and revenues projections are based on the retail performance of stations in the T.T.C. according to on/off passenger traffic and are as follows:

| | Metcalfe, Lyon and Rideau Centre Station | | Bank Station | |
|---|---|---|---|---|
| Lottery | $15,000 | 50 sq ft | $ 20,000 | 60 sq ft |
| Newstand | 20,000 | 100 sq ft | 30,000 | 150 sq ft |
| Fast Food | 30,000 | 200 sq ft | 30,000 | 200 sq ft |
| Fast Food | --- | | 20,000 | 200 sq ft |
| Other | --- | | 15,000 | 100 sq ft |
| | $65,000 | per station | $115,000 | |

It is assumed that these revenues would begin when the system opens. The revenues are projected to grow at a rate of 1.8%. (Rate of retail growth projected in Retail Facilities in the R.M.O.C. by Larry Smith and Associates.) This assumes that the revenues would be based on a percentage of sales and would benefit from sales increases.

The relative differences in the values of these estimated retail sales with respect to each option is the important indicator as to the impact of each option. The tunnel alignment is marginally better than a cut-cover Albert Street alignment, but significantly better than other option/alignment combinations. This indicator is reflected in the retail sales statistic. In general, the elevated option fares very poorly. The Albert/Slater tunnel alignment is the preferred alignment from this analysis.

## 11.6 Negative Impacts

In most options, the total benefits of the grade separated system outweigh the negative impacts. The real effects of these negative impacts should be understood. The measurement of changes in retail sales suggest that a substantial number of businesses will either fail or face severely reduced volumes with the elevated and cut-and-cover option during the construction period.

The businesses which will be most severely affected during the construction period are the convenience or semi-convenience operations which are located in the primary area of impact. Except for some very strong convenience stores, all in this category can be expected to go out of business. The negative impacts on retail sales between start of construction and the year 2001 clearly indicate that the tunnel option will impose the least negative impact.

## 11.7 Summary and Conclusions

Table 11.2 presents a summary of major impacts.

- The construction of a grade separated transitway in Ottawa-Carleton will have a positive effect on the Region's economy. Macro economic studies of similar projects in the U.S. and Canada have indicated a multiplier effect equal to approximately 3.5 times the construction value. Thus, all three options represent an opportunity to achieve this gain, but some alignments may precipitate individual or localized adverse impacts. This positive impact is tied to construction in general, not specifically a transit project.

- Retail sales of businesses in the Central Area will be adversely affected during the construction period, and in the case of the elevated structure the adverse impact will continue after construction. The extent of the

## TABLE 11.2

## SUMMARY OF RETAIL/COMMERCIAL BUSINESS IMPACTS

RETAIL/COMM. BUSINESS IMPACT

EVALUATION ANALYSIS

OPTIONS

| ITEM | CUT COVER | DEEP TUNNEL | ELEVATED |
|---|---|---|---|
| Change in Retail Sales | All retail establishments along alignments were classified as convenience, semi-convenience and destination stores and sales levels estimated according to industry data. Impacts are in two time periods a) construction, b) after construction. | | |
| | During construction impact can be very adverse on convenience stores, and less, but still strongly adverse on semi-convenience. | During construction, impact will be limited to station areas. | During construction, impact will be very adverse to convenience and semi-convenience outlets. |
| | After construction, positive impact at areas of high pedestrian activity. | After construction, positive impact at areas of high pedestrian activity. | After construction, street will be permanently lowered in attractiveness and nature of retailing will change. |
| Change in Retail Wages | Wages are generally in direct proportion to sales and will move in same way. | | |
| Change in Assessed Value of Comm. Bldg. | For both these options, no impact is estimated during construction. After construction, selected locations will have improved accessibility and this will be a positive factor in building value. | | . negative impact on floors 1-5<br>. estimated reduction in value is 25% for existing properties (equivalent to lowering class of building). |
| | Assessment values were tabulated on a block by block basis. Alignments with commercial buildings that could be upgraded by positive impacts would show positive impacts. Alignments with significant amounts of Government Buildings would not exhibit same potential for upgrading. Impact is also related to change in rate of growth of assessed value. Impact measured on Primary Blocks (adjacent to alignment) and Secondary Blocks (next to Primary Area). | | |
| Change in Comm. Taxes | This is directly linked to Assessed value and measures the Tax revenue to the City. Impact is proportional to Assessed Value as noted above. | | |
| OC Transpo Retail Income Gain | To extent that design would allow space to be developed this will be positive. It is estimated that with cut/cover and deep tunnel, impact is positive. | | |

impact will be a function of the alignment chosen, the length of the construction period, and the method of construction.

- The tunnel option on Albert and Slater Streets is preferred because the estimated change in retail sales shows the greatest growth potential.

- Alignments which use Queen Street have the highest negative impacts on the retail sector. The Albert/Queen Street Cut-and-Cover has severe negative impacts.

- The elevated option on Slater Street is not recommended because:

    - it has the least positive impact on retail sales.
    - it has relatively high negative impact on retail sales during construction.
    - the value of potential retail development on Slater Street will be severely reduced.
    - it is the only alignment which has a permanent negative impact on the value of the surrounding commercial buildings.

- A Slater Street alignment particularly for the underground options is very important because approximately 70% of the commercial assessment value in the core area is located on the adjacent blocks.

- Slater Street is important to the future development potential in the study area. Seven out of nine of the blocks which have been identified as having development potential, border on Slater Street.

- Queen Street offers the least amount of potential for increased retail/commercial development because:

    - major buildings along this street reduce the development and redevelopment potential along the alignment.

  - only two blocks along this alignment have been identified as having major development potential. One is already slated for construction (Canlands).
  - the existing retail sector is for the most part relatively fragile so construction disruption will have the most negative impacts.

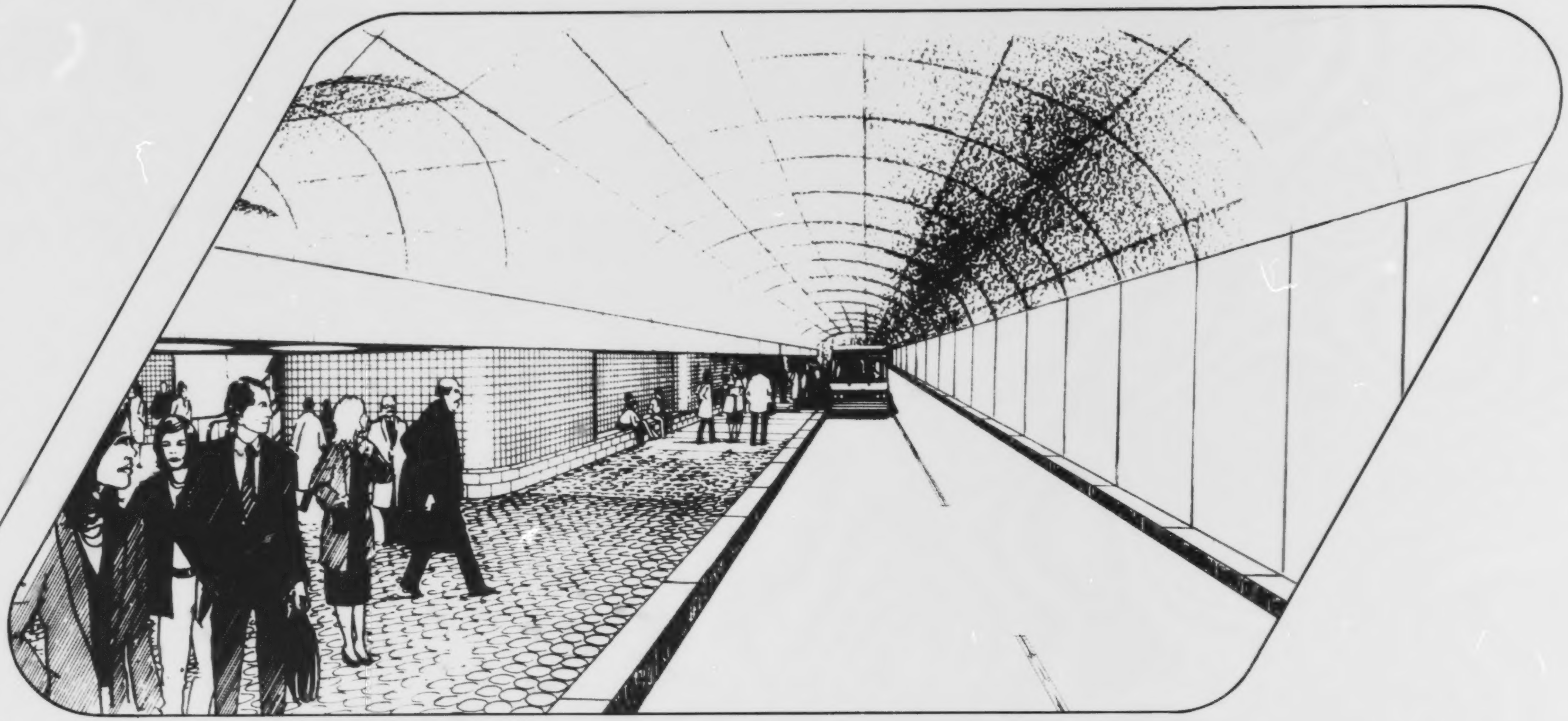
- For all options, businesses will experience some disruption during construction with respect to employee and visitor access to buildings, but construction techniques can minimize this inconvenience.

- For all options, there is not expected to be any Regional loss of retail sales, but the location of purchase will be influenced by the construction activity.

- The cut-and-cover and elevated construction techniques will present severe impacts on retail businesses along the selected corridor. For these two options, many convenience and semi-convenience stores could possibly go out of business during construction as shoppers will avoid the construction areas to purchase those goods at other conveniently located outlets.

- For all options, there is potential for a minor amount of customer related convenience retail in some of the stations. This retail is not considered a threat to the viability of any surface retail. For the elevated option, this retail space was excluded to lessen impact of the structure.

- For all options, there will be a need for a very well organized and effective public information campaign that must be implemented to provide assistance to businesses, visitors and shoppers during this period of construction, particularly with the cut-and-cover and elevated options.



# CHAPTER 12

# 12.0 COMPARATIVE CAPITAL COST ANALYSIS

## 12.1 General

A major factor in the evaluation of the three options is their relative capital costs. The estimating procedure has consequently been structured so as to give a high degree of confidence to comparative costs. In order to prepare an accurate construction cost estimate, it is necessary to have in addition to a clear scope of work, a firm implementation schedule as inflation plays a key role in the actual cost of any project. As the determination of the precise scope and a final schedule is outside the scope of this feasibility study and as the timing of construction is to a great extent dependent on funding from levels of government other than the Regional Municipality, only a base year (1988) comparison can be provided. This analysis is suitable for comparing the relative costs between different options but is not, as such, suitable for financial budgeting purposes.

The project planning and estimating methodology, consistent with the Region's Transitway Programme Management Systems (TPMS) concepts, focuses on the development of a comprehensive Work Breakdown Structure (WBS) which reflects the scope of each of the conceptual options. In order to make the comparison, quantities have been measured where practicable and unit costs applied. In other cases, allowances have been made on a lump sum basis. Unit costs and lump sum allowances were derived from a number of sources including:

- current Transitway contracts;
- similar work in the Ottawa area;
- similar work in other cities of Canada, USA and Europe;
- manufacturers' and suppliers' prices.

The costing comparison is based on conceptual drawings with only limited details of the final product and the sub-surface conditions along the route. Consequently, a judgment of risk was applied to each element to allow for cost variations which may arise due to the need for greater quantities of material, more complex structures or more costly equipment and material than can be foreseen at the concept stage. The risk factors were based on the opinion of experienced design and construction engineers. A contingency factor was also applied to each major element of the work to allow for items of work not identified at the concept stage.

The costing comparison is based on June 1988 unit costs, and contains no allowance for inflation. The resulting analysis is suitable for comparing relative costs of the different options. The data are not suitable in this form for funding analyses or financial budgeting purposes. In order to do so, project timing, construction schedules and inflation rates must be incorporated. This process is not part of this study. As an element of future work, the Regional Municipality will be analyzing several possible scheduling/funding alternatives in order to arrive at an escalated capital cost which can then be utilized for financial planning purposes.

## 12.2 Option Cost Comparison

The cost comparison based on unescalated June 1988 figures is as follows:

| | |
|---|---|
| Tunnel Option | recommended |
| Cut-and-Cover Option | +20% |
| Elevated | -10% |

These comparisons contain no allowance for losses to businesses along the route either during construction or after the project is complete. Nor do they include the costs associated with increased operating costs by OC Transpo and user costs incurred by transit passengers and other street users during a construction period of 3 to 4 years. For the selected tunnel option, these losses are expected to be minimal during construction.

## 12.3 Basis of Comparisons

The basis for the preparation of the comparative costs is as follows:

### 12.3.1 Property and Right-of-Way

(a) Acquisition:

The Central Area Transitway options are generally located within the existing road allowances. Some property will be required for stations, station entrances, ventilation shafts and work sites, where they are located on private lands or lands outside the control of the City of Ottawa and the Regional Municipality.

Plans were prepared showing the approximate property required for each option and a real estate specialist was retained to place a value on each of the properties.

Property requirements for each option were kept to a minimum. However, on completion of the project, some portions of the acquired property could be surplus. These lands could be sold or put to other municipal uses. No allowance has been made for recovery of cost from the sale of surplus lands.

Other normally anticipated acquisition-related costs were also allowed for: compensation, land transfer tax, lease buy-outs, legal and appraisal services, and legal surveys.

(b) Right-of-Way Preparation:

In order to prepare the site for construction, some business accesses may have to be relocated or altered. The Rideau Centre access is one such potential relocation. As an example, depending upon the construction method selected for the construction of the Rideau Centre Station under Daly Street, some access alterations will be necessary. For the elevated option, Ottawa Hydro and Ontario Hydro substation entrances on Slater Street will have to be relocated. For other station access points in the Central Area, the amount of disturbance will be a function of the construction method, and entrance location. Should access points be developed off the street right-of-way and on currently undeveloped property, disturbance can be kept to a minimum. It is not anticipated that any structures or obstructions have to be demolished as part of the right-of-way preparation.

(c) Environmental Protection:

Due to the implementation of the Central Area Transitway, special measures may have to be undertaken to protect existing buildings, equipment, and the public from undue noise and vibration intrusion as well as air quality degradation during and after construction. Environmental protection is a concern particularly with the elevated option due to close proximity of the structure to office buildings along the corridor. Such items are double glazing, vibration control joints and connections, etc., would be required. No techniques are available to mitigate the visual impacts.

(d) Property Maintenance:

It is likely that property will be purchased some years before construction actually begins in order to protect the right-of-way. These parcels of property which can be more accurately defined in the next phase of the design process will then have to be maintained and an associated cost will be incurred.

### 12.3.2 Construction

(a) Running Structure:

At either end of the Central Area Transitway, there are sections of surface works connecting the existing transitway to the grade separated options. These surface works were analyzed from the existing transitway to the tunnel and cut-and-cover portals and to the abutments of the elevated structure. The analysis was based on prices experienced in 1988 for comparable road and structural work.

The tunnel option includes a short section of cut-and-cover construction from each portal to a point where there is sufficient cover to commence tunnelling. At the west end, rock tunnelling commences at the end of the cut-and-cover work. At the east end, there may be a short section of earth tunnel due to a change in the profile of the bedrock. Additional geological information is required to confirm the limits of the various construction methods. For purposes of scope definition, the tunnel itself has been divided into two sections, east and west of the Canal.

The cost of driving tunnels was based on the use of a Tunnel Boring Machine (TBM) which limits the amount of blasting required. When more geological information on rock quality is obtained, better conclusions on the merits of TBM versus drill and controlled blasting (New Austrian Tunnelling Method - NATM) can be made. In fact, it may be desirable to call for alternative bids on the various methods of construction in order to secure the lowest competitive contract price. Some drill and controlled blast excavation will be required in any event in the station excavation work.

The cut-and-cover option includes similar surface sections to those proposed for the tunnel option. Portals are located at approximately the same points for both options. The cut-and-cover option has been divided into two sections, east and west of the Canal. In some cases in order to attain curve radius guidelines, the transitway passes under buildings and these will require underpinning to support them while construction is carried out. Temporary decking of streets to maintain surface traffic and support utilities while construction proceeds would be used.

The elevated option is based on reinforced and post-tensioned concrete construction. The elevated option includes an allowance for the construction of a long span bridge of high aesthetic quality over Elgin Street. This would be required to mitigate the environmental impact of an elevated structure at this point.

Noise and visual barriers have been provided on the elevated structure and the cost of a snow melting system has been included in the analysis along the full length of the elevated structure.

(b) Stations:

For the tunnel option, the four stations (Rideau Centre, Metcalfe, Bank and Lyon) were analyzed on the basis of tunnelling both the platform sections and the connecting passageways between them where required. A minimum possible amount of cut-and-cover work is anticipated for station entrances and ventilation shafts. More detailed design studies will be required to assess the geological features of the rock, and the tunnel elevation to establish the amount of rock cover and set the construction technique.

The cut-and-cover option will also have four stations in the vicinity of Lyon, Bank, Metcalfe, and the Rideau Centre. These station construction areas will require cut-and-cover construction techniques and normal street traffic will be possible once the temporary deck is in place.

An additional fifth station is included for the elevated option at Booth Street because it will be necessary to completely rebuild the currently planned station which will be in operation for a number of years prior to the grade separated option reaching the site. With the two sub-surface options, the currently planned Booth Street station can be designed and constructed to accept the transitway as it leaves the downtown area and thus avoid reconstruction costs. Costs of the elevated stations include the construction of canopies over the station platforms.

(c) Primary Ventilation:

Primary ventilation is applicable to the tunnel and cut-and-cover options only. The conceptual system consists of intake and exhaust structures and associated system controls. Ventilation at the stations is included in the station analysis.

(d) Local Roadway Modifications:

Roadway modifications with the tunnel option are associated with the detour arrangements at the portal areas, particularly in the east, and localized work in the vicinity of the station and ventilation structures. For the cut-and-cover option, very extensive roadway modification is required for utility work, as well as to accommodate the structure construction itself. The major part of both Albert and Queen Streets would be torn up and replaced with a wooden deck. The deck would be in place while the structure and stations were constructed and then the deck would be removed and a new roadway rebuilt when the structure and stations are closed in.

The elevated option will require extensive road reconstruction in the vicinity of all the columns. The entire street would be rebuilt during the project.

During construction of the elevated deck, and the placement of the large deck pieces, entire sections of Slater Street would be closed to traffic for extended periods. During this time, extensive traffic detours will be required that will cause severe problems for OC Transpo operations, as well as for general street traffic.

(e) Modifications to Existing Structures:

Modifications to the Department of National Defence building, National Arts Centre and Ottawa Technical High School overhead walkway will be encountered in the elevated option. No major building modification work is expected for either the tunnel or cut-and-cover option. Modifications will be necessary where entrances to stations are incorporated into existing buildings, where these opportunities are available.

### 12.3.3 Utility Relocations

In order to construct the Central Area Transitway, utilities in the selected streets will have to be relocated, supported and reconstructed. In some cases this may require extensive roadway/utility work on adjacent streets where utilities are relocated to. Preliminary estimates for this work have been prepared by the various utility authorities.

Major utility efforts are required in the case of cut-and-cover since a major portion of the streets must be excavated to allow for the construction of the structures. The elevated structure will also require relocation of utilities to allow for the construction of columns and footings along Slater Street. The University of Ottawa Utilidor may be affected by the alignment north of the Campus Station, and provision for altering it is included in the analysis.

In the cut-and-cover option, a major effort both in time and cost will be required to relocate the Bell Canada utilities outside their building on Albert Street. Discussions with the utility have pointed out the extensive amount of work, and the delicate and sensitive nature of the utility, to say nothing of the need for security during the construction period.

In the case of the tunnel option, much of the work can be carried out in solid rock under the utilities without disturbance. However, the construction of station entrances and ventilation shafts will require the relocation of some utilities in the specific areas where these accesses are on the public right-of-way. Should stations or access points be able to be developed in currently undeveloped property, these utility disruptions can be minimized or perhaps avoided.

### 12.3.4 Engineering and Project Management

(a) Design:

Design allowances include the costs of carrying out the feasibility planning, functional design and detailed design functions to allow the construction of the project to be undertaken. Included are:

- Feasibility Planning: This includes all studies and related concept evaluation costs incurred and anticipated.
- Functional Design: Functional Design includes the development of the project in sufficient detail to define the property requirements; develop the scope of work necessary to prepare a comprehensive estimate; develop a contracting strategy (schedule); and prepare a Baseline Budget.
- Detailed Design: This work includes all design effort required for the preparation of contract documents and assistance with contract tendering.

(b) Construction Management:

The organization required to supervise the contractors, report progress, certify work for payment, coordinate the work of authorities and contractors and test materials has been examined. Included are all indirect costs associated with this effort.

(c) Public Communications and Public Relations Programme:

A project of this scale will require an extensive program of Public Communications and Business Community Relations to ensure that the public and business community are fully informed at all times and that their concerns are met in a most expeditious and satisfactory way.

(d) General Management and Administration:

The Regional Municipality will incur costs of administering the Central Area Transitway from inception to completion. The costs of setting up and operating a project management office are also included.

## 12.4 Comparative Analysis

The bottom line of the comparative cost analysis shows that the elevated option is about 10% less than the tunnel option and that the cut and cover option is about 20% more.

The following observations were relevant. Property costs are much more significant for the elevated option, and this is purely a function of the larger property requirements and the significant amount required for environmental protection to adjacent properties to mitigate the effects of the elevated transitway. Experience has shown property costs to be higher and mitigation measures more elaborate than in earlier projects.

Because of the significant amount of environmental impact on adjacent buildings, the risk factor associated with the elevated option is higher and accordingly the cost estimate subject to greater degree of uncertainty.

The construction costs are highest for the cut and cover option which reflects the more complex construction method. The utility costs for the cut-and-cover method of construction are the highest. This type of work carries with it a high risk factor as traditionally, utility work proves more difficult than first assumed, more time consuming, and often presents surprises in the existence of and location of utilities.

### 12.5 Project Schedule and Funding Requirements

The analysis was developed for each of the options for the purpose of comparison among the three basic options.

All rates, prices and allowances represent June 1988 prices thus reflecting the hypothetical situation of all work being undertaken at the same point in time. No work schedules were assumed and consequently no allowances for inflation or time related contingent reserves established.

In order to assess comparative construction impacts on the downtown area, a preliminary construction sequence was developed for each of the options. Normal construction shifts were assumed. No financial constraints were considered.

**Exhibit 12.1** illustrates a possible preliminary schedule for the tunnel option assuming reasonable engineering and approval durations. No financial restrictions are reflected. This shows that from the commencement of functional design, construction could possibly start in four years with an operational date three to four years later.

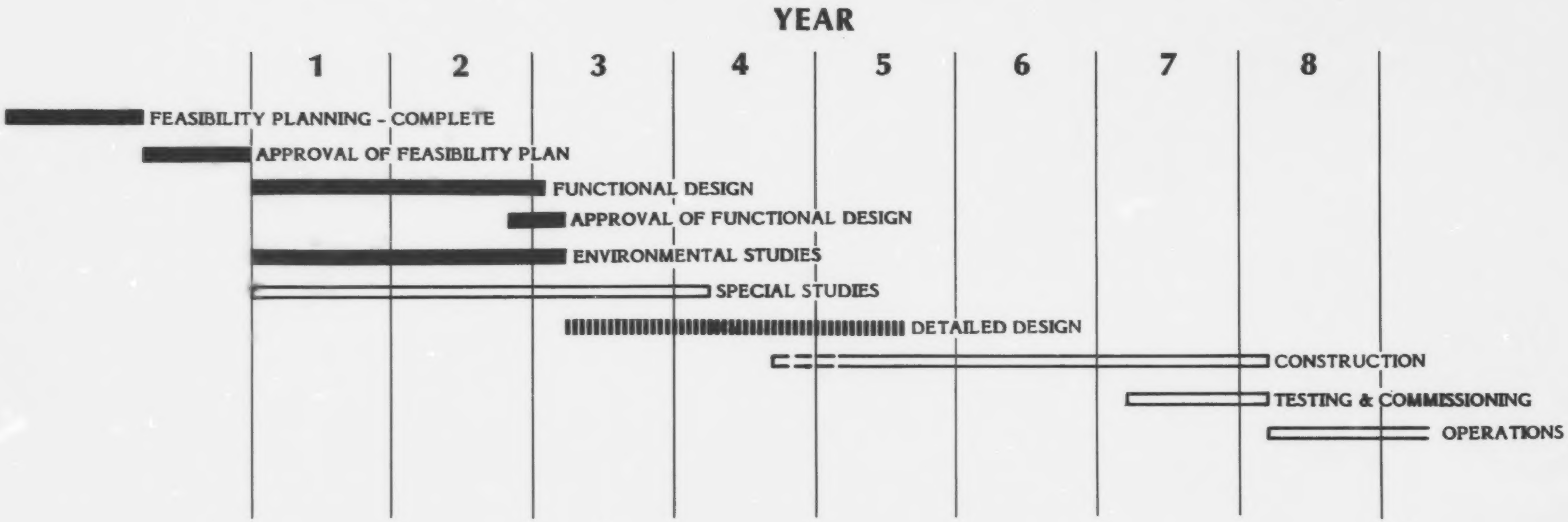
The indicated schedule would assist in developing an escalated cost estimate and corresponding cash flow forecast. However, considerable additional work is required in order to arrive at a coprehensive project scope and to arrive at a balance between construction sequence, escalation, financial requirements, and a cash flow compatible with the Region's overall capital works programme.

### 12.6 Baseline Budget

Once the project proceeds into the functional design phase, sufficient scope definition will become available to enable the development of a Baseline Budget. The additional information will include:

- resolution of system configurations (alignment, profile, cross-sections, etc.);
- confirmation of property requirements;
- refinement of project scope (station details, etc.);
- soils information;
- engineering designs;
- confirmation of construction methods;
- project-timing; and
- unit cost/inflation trends.

EXHIBIT 12.1



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## POSSIBLE PROJECT SCHEDULE

# CHAPTER 13

# 13.0 COMPARATIVE EVALUATION AND SELECTION OF PREFERRED OPTION

## 13.1 Introduction

During the concept development phase of the project, numerous alignments and concepts were developed. These were subjected to an initial screening process which reduced the number of alternatives. This initial screening process utilized a number of criteria, primarily related to the environmental impacts, as well as engineering factors such as grades, curvature, geology, etc.

As a result of this initial screening process, a short list of alternatives for each of the three options, elevated, cut-and-cover and tunnel was prepared and these alternatives were then studied in more detail in the second phase of the project. As this more detailed examination took place, more information was developed on the alternatives and on their potential impacts. This refinement process also involved an evaluation of the various alternatives within each option. This second level of evaluation identified the preferred elevated, cut-and-cover and tunnel options from among the alternatives studied in more detail.

A set of criteria was identified during the concept development and refinement process. Some of these criteria were applied to the three options in previous chapters when evaluating the potential impacts on real estate (Chapter 10), and retail, commercial business enterprises (Chapter 11) and relative construction costs (Chapter 12). This chapter utilizes other criteria related to:

- Indirect Costs of Implementation;
- Operations;
- Urban Design/Urban Environment;

and presents a comparative analysis of each of the three options. The process was intended to provide additional information on each option that would be useful in selecting an overall preferred option.

## 13.2 Indirect Costs Associated with Implementation

Table 13.1 lists a number of cost categories that should be considered in the overall evaluation of the options. It is difficult to accurately quantify some of these costs as in some cases the costs are borne by individuals in increased vehicle operating costs or excessive travel time.

**TABLE 13.1**

**INDIRECT IMPLEMENTATION COSTS OF OPTIONS**

| | Tunnel | Cut Cover | Elevated |
|---|---|---|---|
| Implementation Costs | | | |
| a) Surface disruption costs | Low | High | High |
| b) Potential for legal actions due to disruption | Low | High | High |
| c) Cost of traffic/transit disruption | Low | High | High |
| d) Concessions due to construction disruption | Low | High | High |
| Post Implementation Costs | | | |
| a) Real estate tax loss | Nil | Nil | High |
| b) Depressed business climate in corridor | Nil | Nil | High |
| c) Impact on development potential in corridor | Positive | Positive | Negative |

The implementation costs are difficult to quantify but they consist of at least the elements mentioned in the table. The Seattle example suggests that a very comprehensive program has to be in place to respond to the shopper-business-commercial interests in the construction zone. For both elevated and cut-and-cover options this will have to be at a very high level. For the tunnel option, the program will be required for the station areas and for some areas on the portion east of the Canal. This disruption is not expected to be as long or nearly as extensive as for the other two options.

The two options that involve considerable street disruption, cut-and-cover and elevated, both present opportunities for legal action on behalf of those adversely affected. The Seattle experience indicates again that an intensive preparation program could be initiated to lessen this potential problem. Elements of the program involve pre-emptive purchase of property; rapid, on-the-spot settlement of claims, and a very positive public information program to advise the public and the retail sector of the nature, extent and duration of the construction phases that impact each area. The tunnel option program is much reduced in scope and would apply to station areas and some access east of the Canal. Even at stations, if they are developed offstreet, the disruption and hence the potential for legal claims, is minimal.

There will be considerable potential for extensive traffic and transit disruption during the construction phase of the elevated and cut-and-cover options. These disruptions will impose a cost on street traffic users, private autos, buses, delivery trucks, taxis, etc. The potential for this level of disruption with the tunnel system is very much reduced.

Finally, in this category of implementation costs, there is the cost of concessions given to various parties to offset the impact of the construction program. These concessions could be: reduced tax assessment during period of disruption; and participation by the government in business promotion campaigns. These programs are probably not required with the tunnel option.

In the post construction period, the concensus is that there would be a continuing negative impact on taxes and on development potential due to the presence of an elevated structure.

In summary, the tunnel option is preferred, because it carries with it the lowest potential for negative implementation impacts and maintains the highest development potential.

There are several other cost related issues. The first of these is cash flow during construction. It is most likely that if either cut-and-cover or elevated options were chosen, that there would be significant pressure to accellerate the construction schedule to reduce the length of time that the disruption requires. This would no doubt require a compressed work schedule in an attempt to accommodate those most affected but it would also require larger cash flow. It would also permit faster capture of the benefits. The tunnel option has the possibility of being extended in construction time at no increase in disruption. Accordingly it is possible, if desirable, to stretch out the cash flow requirements during construction. A four year or longer implementation program is possible if desired.

## 13.3 Other Implementation Impacts

Besides the indirect costs associated with the Transitway construction program, there are other costs, perhaps less tangible, but nevertheless real costs to those who incur them. It has already been generally accepted that a grade separated transitway would be beneficial in the global sense, and the Central Area as a whole would benefit. This section identifies those who are adversely impacted and the nature of those impacts, not from the facility itself, but from the construction of the facility.

Life and business in the Central Area has to go on, and it is recognized that major disruptions of a similar magnitude have occurred in other cities, and they survived. One of the objectives is to minimize the "implementation pain" for all involved, and if one option presents an opportunity to accomplish that, so much the better. Table 13.2 identifies the parties that could be impacted along with a general description of the nature of the impacts.

## TABLE 13.2

## SUMMARY OF OTHER IMPLEMENTATION IMPACTS

| Party Impacted | Natures of Possible Negative Impacts |
|---|---|
| Transit Passenger | - disruption of passenger access in Central Area<br>- increase in travel time<br>- unpredictability of service |
| Transit Operator | - increased travel time<br>- increased demand for vehicles<br>- increased capital and operating costs |
| Auto Driver, Truck Driver | - increased travel time<br>- reduction in parking spaces<br>- reduction in curb space<br>- circuitous routing |
| Merchant/Hotel Owner | - loss of business<br>- decreased visibility of premises |
| Business Office | - more difficult access to premises<br>- increased congestion for truck, courier service |
| Shopper/Tourist | - more difficult access to stores and facilities in construction area |
| City/RMOC | - strong requirement to provide support to affected bodies<br>- possibility of legal suits in seeking compensation for damages, and loss of business |
| NCC | - possible impact on driveways and on parks<br>- request to accommodate materials and worksite in Lebreton area |
| Employees | - dust, dirt and noise<br>- more difficult passage through construction areas |

Some of these impacts have been identified and qualitatively set out in earlier chapters. Others are very difficult to describe quantitatively.

The negative impacts during construction all relate or stem from the amount of physical disruption to the streets. Clearly the tunnel option is much preferred over both the other concepts. The running way and much of the station construction activity can take place off the street. When street construction is required, it should be possible to confine it to a small localized area where station entrances are required. Depending on the final method of construction the area east of the Canal may experience more construction activity, but here the right-of-way is available to provide detours to be placed.

### 13.4 Operations

The comparison Tables 13.3 to 13.6 identify a number of factors and present some observations against each factor. In summary, transit operations would be severely disrupted during implementation of the cut-and-cover and elevated options, and affected to a limited and controllable manner with the tunnel construction.

All options will provide for much improved service over the existing surface transitway service when completed. The operation in the cut-and-cover and tunnel option will be superior to that available from the elevated option due to:

- lower and shorter grades
- weather protected environment
- passing flexibility at stations
- better passenger facilities
- reduced passenger grade changes.

The tunnel operation will be slightly superior to that achievable in the cut-and-cover option because:

- ability to easily build in maintenance vehicle laybys in the sections between stations
- ability to introduce turnaround cross connections if felt necessary more easily at either end of Central Area
- increased flexibility for conversion modifications in the long term.

## TABLE 13.3

| ITEM | OPERATIONS COMPARISONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| 1. Capacity<br>. Measured by bus and passenger volumes in p.m. peak hour for planning period.<br>. Ability to accommodate higher station passenger volumes. | Grade separated transitway will be capable of providing required capacity to accommodate bus and passenger volumes (one way) - 2001 (180 buses - 9500 passengers) and 2014 (234 buses - 12500 passengers).<br>**This is a function of processing capacity and platform size. Preliminary model tests indicate volume could be pushed beyond 2014 level.** | Grade separated transitway will be capable of providing required capacity to accommodate bus and passenger volumes (one way) - 2001 (180 buses - 9500 passengers) and 2014 (234 buses - 12500 passengers).<br>**This is a function of processing capacity and platform size. Preliminary model tests indicate volume could be pushed beyond 2014 level.** | Grade separated transitway will be capable of providing required capacity to accommodate bus and passenger volumes (one way) - 2001 (180 buses - 9500 passengers) and 2014 (234 buses - 12500 passengers).<br>**This is a function of processing capacity and platform size. Preliminary model tests indicate volume could be pushed beyond 2014 level.** |
| 2. Grades | Meets standards. | Meets standards. | Meets standards. |
| 3. Curvature | Meets standards. | Meets standards. | Meets standards. |
| 4. Coverage<br>Central location, walk distances proximity to growth areas. | . Albert/Queen alignment is good.<br>. Provides good access to Sparks Street. | Albert/Slater alignment better able to serve growth areas. Good potential to access Sparks Street through adjacent development. | Slater Street access is not as central. Unless stations can penetrate block to Albert, this alignment is slightly less desirable. |
| 5. Future Flexibility<br>. Ability to adapt to new vehicle technologies. | Clearances and geometrics are compatible with existing rail technology.<br>Future technology (magnetic levitation) will no doubt recognize current vehicle sizes. | Clearances and geometrics are compatible with existing rail technology.<br>Future technology (magnetic levitation) will no doubt recognize current vehicle sizes. | Clearances and geometrics are compatible with existing rail technology.<br>Future technology (magnetic levitation) will no doubt recognize current vehicle sizes. |
| 6. Operational Flexibility<br>a) Ability to handle unforeseen operational problems. | a) Although passing lanes at stations are not required for capacity, they can be easily provided in these options and that provides significant ability to accommodate unforeseen events, store and bypass disabled buses. | a) Although passing lanes at stations are not required for capacity, they can be easily provided in these options and that provides significant ability to accommodate unforeseen events, store and bypass disabled buses. | a) Passing lanes cannot be provided at station due to row width. |

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**TABLE 13.4**

| ITEM | OPERATIONS COMPARISONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| b) Ability to short-turn in Central Area.<br>c) Ability to accommodate bus breakdown. | b) No turnarounds provided.<br>c) Both options are similar in that they can accommodate bus bypass at station. Breakdown recovery vehicle can be stationed at each end to remove disabled bus when operation permit, or from between stations. | b) Turnarounds can be provided if needed.<br>c) Both options are similar in that they can accommodate bus bypass at station. Breakdown recovery vehicle can be stationed at each end to remove disabled bus when operation permit, or from between stations. | b) No turnarounds permitted.<br>c) No bus bypass at station. Must rely on tow vehicle to remove bus or adapt push-pull technique of guided bus technology to get bus out of system. Tow vehicle service time is extended due to remote access to transitway at west end. |
| 7. Station Flexibility<br>- Access to and from.<br>- Fare collection/control.<br>- Disabled access.<br>- Ability to spread access.<br>- Ability to integrate with other development. | Stations can be developed at good, central, high demand locations. Good fare control can be provided. Elevator access to station platform levels can be developed. Integration with adjacent development is possible and can be achieved. | Excellent station concept with good ability to interface with other developments. Ability to extend access system is good. Fare control system is excellent. | Station access for eastbound travel is not as convenient. Integration into adjacent development is possible, but difficult. Disabled access to platform by elevator is difficult to provide and achieve fare control. |
| 8. Fleet Vehicle Technology<br>. Ability to use existing buses.<br>. Extent of modifications.<br>. New technology required.<br>. Degree of risk involved. | Cannot use existing diesel buses exclusively, but will require alternative fuel or dual mode bus. Current developments with Natural Gas are promising. It is an operational bus. Engine developments are in progress. Other technology (dual mode) is also proven. Risk is considered low. | Cannot use existing diesel buses exclusively, but will require alternative fuel or dual mode bus. Current developments with Natural Gas are promising. It is an operational bus. Engine developments are in progress. Other technology (dual mode) is also proven. Risk is considered low. | Compatible with existing buses. Current diesel power is acceptable. Noise abatement is important. Risk is low. |
| 9. Compatibility with Existing Operations | It is assumed surface operations will be on Albert/Slater. The Albert/Queen Alignment would be able to get passengers to Albert, and may require I block walk on surface to stop locations. Not the best, but acceptable. | The preferred Albert/Slater alignment will be well located to provide integrated services. The reverse running of the buses should not pose a problem because mezzanines are able to accommodate both directions. | The elevated option on Slater may have a bit more impediment unless the plus 15' concept grows. The surface operation on Slater will be jeopardized due to physical impact of columns, etc. Extra walk is not long. |
| 10. Vulnerability to Weather Disruptions | Option offers full weather protection and no difficulties are anticipated. The ramps into and out of facility can be protected. | Option offers full weather protection and no difficulties are anticipated. The ramps into and out of facility can be protected. | Weather protection provided through heated running paths. Problems still exist with structure shedding rain to street below. Much of street below will be weather protected by transitway. |
| 11. Information Systems | For all options, a sophisticated passenger information system in the stations is required for peak period operations. Requirement are well within existing technology, but require specific hardware and software development. | For all options, a sophisticated passenger information system in the stations is required for peak period operations. Requirement are well within existing technology, but require specific hardware and software development. | For all options, a sophisticated passenger information system in the stations is required for peak period operations. Requirement are well within existing technology, but require specific hardware and software development. |

**EVALUATION ANALYSIS**
**TRANSIT OPERATIONS**

## TABLE 13.5

| ITEM | OPERATIONS COMPARISONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| 12. Operational Costs | | | |
| a) Speeds | a) It is assumed that speeds for both options are comparable. | a) It is assumed that speeds for both options are comparable. | a) Speed may slow on long grades approaching from west. This will have small negative impact. |
| b) Staffing | b) No difference in staffing costs are readily apparent. Differences would be related to need for additional manned booths in stations to process p.m. peak period and this is a function of station design and fare medium to be used. Station design for tunnel can be very flexible. | b) No difference in staffing costs are readily apparent. Differences would be related to need for additional manned booths in stations to process p.m. peak period and this is a function of station design and fare medium to be used. Station design for tunnel can be very flexible. | b) No difference in staffing costs are readily apparent. Differences would be related to need for additional manned booths in stations to process p.m. peak period and this is a function of station design and fare medium to be used. Station design for tunnel can be very flexible. |
| c) Monitoring | c) Monitoring of the facility from operations control viewpoint will most likely be done via TV monitoring and this process should be similar for all options. | c) Monitoring of the facility from operations control viewpoint will most likely be done via TV monitoring and this process should be similar for all options. | c) Monitoring of the facility from operations control viewpoint will most likely be done via TV monitoring and this process should be similar for all options. |
| d) Security | d) Security monitoring will likely be similar for all systems. Security will include fare security and the passenger safety monitoring at stations. Station and mezzanine monitoring will also be a function of the amount of joint development. | d) Security monitoring will likely be similar for all systems. Security will include fare security and the passenger safety monitoring at stations. Station and mezzanine monitoring will also be a function of the amount of joint development. | d) Security monitoring will likely be similar for all systems. Security will include fare security and the passenger safety monitoring at stations. Station and mezzanine monitoring will also be a function of the amount of joint development. |
| 13. Maintenance Costs<br>- Station<br>- Line Haul | To the extent that the stations are or can be roughly comparable, all options are probably similar. | Extra costs associated with more or larger escalators. Provision of small maintenance bays along tunnels between stations should permit easy access at all times to problem areas by maintenance crews.<br>Both underground systems will have additional maintenance of mechanical ventilation systems. | Extra costs for exterior maintenance of canopy at station areas and sound barriers between stations. Cannot provide maintenance laybys and thus repairs must be carried out in off peak hours or at night.<br>Facility itself is subject to degradation due to normal weather cycles. This will be an extra cost. Replacement of heating system for roadway must also be provided for. |
| 14. Vulnerability to Disruption<br>. Fire on vehicle.<br>. Fire in adjacent building on Slater Street (elevated). | Both underground options will have full fire safety systems and procedures developed. Short distance between stations, ability to cross over at stations are safety features. | Both underground options will have full fire safety systems and procedures developed. Short distance between stations, ability to cross over at stations are safety features. | Passenger safety systems can be developed to provide safe exit from disabled bus. Ventilation is not a problem.<br>Transitway would have to provide access for fire department to respond to fires along Slater Street. During this time no transitway service can be provided. |

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## TABLE 13.6

| ITEM | OPERATIONS COMPARISONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| 15. Impact on Street Traffic Operations<br>a) During construction<br>b) After construction | a) Very severe disruption to normal traffic patterns during initial and final work activities. General disruption for whole of work period.<br>b) No long-term impact. Returns two arterial lanes to Central Area street system. | a) Limited disruption for most part. Possible disruption at station access but locally confined to single traffic lane. Depending upon construction technique east of canal, could require traffic detours. Detours required north of Campus Station at portal area.<br>b) No long-term adverse impact. Returns two arterial lanes to street system in Central Area. | a) Very severe disruption to normal traffic patterns during initial and final work activities. General disruption for whole of work period.<br>b) Will result in loss of one lane on Slater Street. |

Once it is in operation, a grade-separated transitway, no matter what option, will provide operating benefits to the transit system. Estimates of operating time savings are very positive and indicate that the travel time through the Central Area can be cut in half now, and this savings will become more pronounced as the general street congestion continues to increase. The opportunity to develop passing lanes at all stations except Rideau Centre for both the cut-and-cover and tunnel option is considered to be a significant advantage from an operations perspective. Although the simulation model indicated that the required capacity could be achieved without passing, the ability to pass in a station increases the reliability and flexibility of operation. A disabled bus is able to be bypassed easily at a station. The likelihood of such an event is only expected once every three months, but if it can be easily overcome, service reliability will be better.

Another factor that was considered advantageous, was the compatibility of the surface transit operation with the grade-separated transit operation. It is expected that the surface transit operation will be rationalized after the grade-separated system is in place and will most likely operate on Albert and Slater Streets. Accordingly, the tunnel option would be most compatible with the surface option and provide the transit passenger with a very clear interface between the surface and the transitway routes. This interface is not as direct with either the elevated or cut-and-cover options. The Albert-Slater surface operations would provide an emergency alternative route should the tunnel be closed for some reason.

Operationally, both the underground options are superior to the elevated option in that they avoid the requirement for the very long 3.5 percent grade at the west end. This long grade will slow up the eastbound service. In addition, the elevated option is subject to unannounced interruption by the fire department who would require access to the facility to respond to emergencies along Slater St. During these times, transitway service would have to cease, or revert to surface streets. In either case, less than desirable operations would result.

Another area where the elevated option imposes a burden on the remaining surface operations is with respect to capacity. The columns required to support the elevated system will remove one lane of capacity from Slater Street. The other two options actually provide the equivalance of two new lanes to the downtown street system. Thus the difference between underground and elevated options is three surface lanes. The cost of providing three surface lanes of capacity in the central area is enormous, it if were practical at all. Thus the removal of a lane is serious.

In summary, the evaluation of the options, from the transit operations viewpoint clearly indicates that an underground option is superior to an elevated option. In addition, the tunnel option has marginal benefits over the cut-and-cover option.

### 13.5 Urban Design/Environment

The comparison of options on the basis of urban environment and design factors is presented in Tables 13.7 to 13.8. It is very clear that when considering above or below ground options, the elevated option is a poor choice. It seriously impacts virtually every criterion that was established.

An extensive analysis and consultation process has resulted in a very clear choice between the elevated versus underground options. The tremendous adverse impact of the elevated concept in almost every evaluation category clearly affects its acceptability.

Besides violating many of the desirable urban design criteria established by the Regional Municipality of Ottawa-Carleton, the City of Ottawa and the National Capital Commission for the National Capital area, the elevated option does not offer any offsetting technical or operational advantages.

The two underground options do not impose any adverse impacts with the exception of the necessary ventilation structures, and these can be very well located and designed so as not to be a problem. The selection of a preferred

## TABLE 13.7

| ITEM | OPTIONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| 1. Noise Impacts | Both underground options are expected to exhibit essentially similar noise characteristics. Noise, a function of the vehicle has been exhaustively sampled and monitored. Both options will improve urban street level noise environment. | Both underground options are expected to exhibit essentially similar noise characteristics. Noise, a function of the vehicle has been exhaustively sampled and monitored. Both options will improve urban street level noise environment. | Noise at the 2nd, 3rd or 4th level of buildings will be a real problem due to inability of building facades to reduce or stop noise at that level. Vibration could also be a problem. A sound barrier will be a requirement to capture noise at that level in central area. Stations will have canopy. |
| Vibration | The U/G options will present little problem with vibration. If structure is not connected to the buildings, little chance of vibration disturbances are possible. Tunnel operation, on rubber tires, in solid rock will be quite safe from vibrations. Future LRT or rail operation could require "floating slab" construction technique to dampen vibration. Provision can be made for this in design. | The U/G options will present little problem with vibration. If structure is not connected to the buildings, little chance of vibration disturbances are possible. Tunnel operation, on rubber tires, in solid rock will be quite safe from vibrations. Future LRT or rail operation could require "floating slab" construction technique to dampen vibration. Provision can be made for this in design. | The elevated structure will have to be physically separated from buildings and must also be of massive structural concrete construction in order to minimize vibration. |
| 2. Historic Buildings Impact | Both options are expected to have minimum impact. Construction activities immediately east of Rideau Street on Daly Avenue may require underpinning or other subsurface work but no major impacts on surface buildings is foreseen. Similarly at west and between Lyon and Bronson on north side of Queen, and south side of Albert, there are Heritage structures that may be inconvenienced during construction, but no lasting adverse impact is expected. | Both options are expected to have minimum impact. Construction activities immediately east of Rideau Street on Daly Avenue may require underpinning or other subsurface work but no major impacts on surface buildings is foreseen. | Elevated option will adversely impact buildings on western fringe of U. of O. by developing a barrier and putting a noise source at an elevated position along [illegible] residential use building. |
| 3. Ceremonial Route | Neither option would impact facility. Both options offer opportunity to enhance Ceremonial Route by assisting in the relocation of buses off Wellington St. | Neither option would impact facility. Both options offer opportunity to enhance Ceremonial Route by assisting in the relocation of buses off Wellington St. | Elevated option will overpass Elgin Street and depending on design of structure could be a positive or negative factor. General opinion is that the structure would negatively impact route.<br>Route over Canal is also expected to be a major negative feature as it impacts historic Canal views and precinct. |
| 4. Open Spaces<br>Parks<br>Recreation Land | No impact except where western approach leads to Lebreton Station and this can be handled with good Landscape design. | No impact except where western approach leads to Lebreton Station and this can be handled with good Landscape design. | Very significant adverse impact on Confederation Park, a most important urban green space in CBD.<br>Very significant (adverse) impact on Technical High School playing field.<br>Significant impact on Lebreton Flats with very long approach structure and elevated Lebreton Station at Booth St. |

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CENTRAL AREA TRANSITWAY
GRADE - SEPARATION FEASIBILITY STUDY
DELCAN

EVALUATION ANALYSIS
URBAN DESIGN AND
ENVIRONMENT FACTORS

## TABLE 13.8

| ITEM | OPTIONS | | |
|---|---|---|---|
| | CUT AND COVER | TUNNEL | ELEVATED |
| 5. Views/Vistas | No impact. | No impact. | Very significant adverse impacts on many important views along entire route. Passenger views from the buses may be improved. |
| 6. Air Quality | All options will have beneficial impact on air quality at street level by virtue of removing that volume of buses from the street.<br>Additional benefit in use of natural gas in vehicles. Need to carefully design and locate exhaust air vent shafts, but options to achieve satisfactory concept exist . | All options will have beneficial impact on air quality at street level by virtue of removing that volume of buses from the street.<br>Additional benefit in use of natural gas in vehicles. Need to carefully design and locate exhaust air vent shafts, but options to achieve satisfactory concept exist . | All options will have beneficial impact on air quality at street level by virtue of removing that volume of buses from the street.<br>Use of conventional buses is proposed for elevated option. |
| 7. Pedestrian Environment on Street | May improve if additional space allocated to pedestrians. Will also provide additional opportunities to access transit system. Will reduce/remove concentration of transit passengers at surface stops. | May improve if additional space allocated to pedestrians. Will also provide additional opportunities to access transit system. Will reduce/remove concentration of transit passengers at surface stops. | Very severe degradation along route due to overpowering influence of structure and adverse rain, snow, etc., patterns on street. Support columns impede surface circulation. |
| 8. Urban Area Cohesiveness | May provide connecting linkages and result in improved all weather connections. | May provide connecting linkages and result in improved all weather connections. | Will create a large permanent barrier which will divide CBD into two halves, joined by a corridor of urban blight under elevated structure.<br>Will require tremendous effort and design skills to enhance area under structure and reduce impact of structure on adjacent development. |
| 9. Station Integration with Urban Fabric | Excellent opportunities exist for both options. Specific design for specific sites are able to provide excellent integration.<br>Cut and cover option is relatively shallow and may make for more and easier opportunities to integrate transitway with future development. | Excellent opportunities exist for both options. Specific design for specific sites are able to provide excellent integration.<br>Very flexible station and access design concept will facilitate integration opportunities. | Fewer off street sites available. Probably best option is to span cross streets and pick up all corners at intersections. |
| 10. Physical Location vis-a-vis Future Development | Both options under Albert/Queen or Albert/Slater have reasonable access. Future trend is to south, but currently Albert is close to geographic and business centres. | Both options under Albert/Queen or Albert/Slater have reasonable access. Future trend is to south, but currently Albert is close to geographic and business centres. | Slater is south of core, but long-term development will enable Slater St. to serve area well. |
| 11. Future Development | Albert/Queen alignment is ideal for integration with Canlands, Campeau Land.<br>With good station access design, good opportunities exist for both options. | Along Albert/Slater, opportunities exist at Metcalfe behind National Gallery and at other sites along Albert and Slater.<br>With good station access design, good opportunities exist for both options. | Limited opportunities to interface with Canlands or Campeau Site. |

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## EVALUATION ANALYSIS
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## ENVIRONMENT FACTORS

underground option, on this criteria, relates to how well each option permits the development of a transit access network that best supports a desirable pattern of development through the Central Area. In addition, the transitway access and egress system should be flexible enough to promote integration with future development. Both underground options provide a good opportunity to achieve the desired level of physical integration with the urban development as it is now and as it may develop in the future. From this point of view the tunnel option under Albert and Slater offers a preferred alignment for the following reasons:

- More development opportunities can be accessed from Albert-Slater than from Albert-Queen.
- The more southern location better serves the long-term as the growth trend is to the south.
- The tunnel station concept is a generic concept that features an intermediate level that can be utilized to develop a pedestrian tunnel connection on a wide basis either within a street right-of-way or integrated with private development.

In summary, from the urban environment and design viewpoint, it is clear that an underground option is preferred. Between the underground options, a tunnel option is preferred.

## 13.6 Summary and Conclusions

### 13.6.1 Summary

- Other costs of implementation tend to be unquantifiable at this point, but support the selection of the tunnel option.
- Long-term impact costs favour the underground options.
- All urban design, environmental criteria and many operational criteria indicate that the elevated option should not be selected. The additional non-quantifiable costs of the elevated option include:
  - severe impact on transit operation during construction;
  - severe impact on urban environment and quality of visual environment along corridor that compromises City of Ottawa and National Capital Commission long-term objectives;
  - severe impact during construction on all business along route, with many convenience retail stores possibly going out of business;
  - severe impact after construction on market value and potential of all property along route;
  - loss of estimated $4 million a year on taxes from reduced value of property along corridor.

  It is recognized in this analysis that the elevated option will, by virtue of the fact that it provides a grade separated connection between the eastern and western portions of the Transitway, provide a net benefit to the Central Area at the cost of the impacts stated along the affected corridor.

- The tunnel and the cut-and-cover option have the ability to provide comparable transit service to the Central Area. The elevated option will always be subject to disruptions which will not affect the underground options.
- From the operations viewpoint, the underground options are preferred over the elevated option, and the tunnel favoured over the cut-and-cover.
- The long-term flexibility of the tunnel concept is considered to be superior to that of the cut-and-cover option for the following reasons:
  - tunnel cross section is more easily altered if required to accept new technology
  - station concept can more easily support additional and expanded entrances and achieve easy integration with new developments
  - possible to introduce service bays if required, at low cost.

- The disruption during construction with the cut-and-cover and elevated is very much more severe than with the tunnel. Extensive street level diversions for extended periods will be required for both cut-and-cover and elevated. During this time many retail businesses that rely on easy pedestrian access will suffer. Very agressive support programs by the RMOC and City could help to reduce the impact. Transit operations will also be very severely affected.
- From the environmental and urban design viewpoint the elevated option should be avoided, almost at all costs.
- The underground options involve little long-term environmental damage, but the tunnel option offers some unique access/egress configurations that can be very useful in distributing the impact of the passenger flows over a wide area.
- The elevated option will incur long-term degredation due to exposure to the elements. This will require superior maintenance efforts to keep the appearance of the facility up to a high standard, so that it does not affect, any more that it would by its very presence, the surrounding urban environment.

### 13.6.2 Conclusions

The evaluation process adopted for this feasibility study included a wide range of factors. The following conclusions are related to these evaluation areas:

#### Construction Costs

The comparative cost analysis undertaken was done without detailed engineering, architectural or geotechnical investigation. The major cost items for each option were carefully reviewed for risk and are believed to be the very best that can be prepared using available information. Construction cost alone is not a major issue in selecting the preferred option.

#### Transit Operations

Transit operations requirements will be best served with one of the two underground options, with the tunnel option preferred over the cut-and-cover due primarily to operational flexibility and integration with surface operations.

#### Urban Impact

The elevated option should be avoided almost at all costs due to its wide ranging negative impact.

The cut-and-cover option presents very severe impacts during construction over the whole of the business area of the Central Area.

The preferred option is the tunnel option because it offers the potential to develop excellent urban linkages and achieve an operational state with minimum physical disruption.

#### Transportation System Impacts

Both underground options offer superior benefits over the elevated option which results in a loss of one lane of traffic on Slater Street. In addition, the tunnel option has significantly less operational impact on the normal downtown traffic system than the cut-and-cover option. The tunnel option is clearly preferred.

#### Real Estate Impact

The tunnel option is preferred over the other two options because it does not impose a negative feature in the core area, nor does it impose any major short-term problems during implementation. Both underground options present good opportunity for property enhancement.

#### Business/Commercial Impact

The clearly preferred option is the tunnel option.

#### Risk

Clearly, any underground construction carries with it an element of risk due to the unknown nature of the soils. The functional design activities can reduce this risk factor considerably. All information to date indicates that the bedrock is of good quality for tunnelling. The major risk is with the utilities as was confirmed by Seattle experience. The cut-and-cover option has the greatest exposure to this risk, followed by the elevated option.

From all evidence accumulated in this project, the study team's conclusion is that the preferred option is the split-tunnel option with one direction under Albert Street and one direction under Slater Street. This option presents the best opportunities to provide a reliable, safe transitway connection through the Central Area, and enable OC Transpo to provide reliable service in an efficient manner, independent of the level of congestion on the surface streets in the Central Area.

# CHAPTER 14

# 14.0 THE DEVELOPMENT OF STATION CONCEPTS

## 14.1 Introduction

Stations are perhaps the most important consideration in a transitway system. Well designed and located stations provide direct, well identified passenger walkways and a pleasant safe atmosphere. They function as the link between the transit system and the Central Area activities. The network of station access locations can be designed to disperse the passengers along the corridor and bring the transit service closer to more passengers.

In this study, a careful examination of the urban development - existing and proposed - passenger flow patterns, and existing transit stop activity lead quickly to the conclusion that stations were required at Bank Street and Rideau Centre. The need for two other station locations was then obvious in order to obtain appropriate coverage in the Central Area. The proposed stations at Lyon and at Metcalfe provided the balance of the coverage required in the Central Area.

The Bank Street station would be located to support the existing and future retail, commercial and associated pedestrian activities along the Bank Street corridor, as well as provide a convenient location for transfers between the Transitway routes and important north-south surface routes on Bank Street.

The Rideau Centre Station would be designed to accommodate the passenger activity associated with the Rideau Centre, Congress Centre, and Market-Rideau Street complex. The Metcalfe Station has the potential to be the second busiest station serving a growing employment area at the east end of the downtown and also provide an opportunity to extend the pedestrian connections to the east of Elgin to serve the Court and the new RMOC Headquarters building. Transfers to/from Elgin Street transit services could be accommodated in this fashion. Similarly, the Canlands development can be served by this station, and thus link up the Transitway, through Canlands to Queen Street and ultimately to the Sparks Street Mall area.

At the west end of downtown, the station at Lyon could serve the employment centres developing around Place de Ville and the Minto Site, as well as the high-rise residential buildings just to the west.

## 14.2 Development of Criteria for Stations

There were a number of criteria that were identified as being desirable, or in some cases, mandatory for the station concept. Briefly some of these are set out below:

### Physical Size

The preliminary operational studies indicated that the station platforms should have a desirable length of 110 m and width of 6 m. The length was required to provide space for up to 5 bus loading areas, as well as to provide flexibility to accommodate a train or other technology in the future. In the operational analysis, it was determined that space for bus platoons of 3 or 4 buses would be satisfactory from a capacity viewpoint, but that the extra berth would provide a spot to store a disabled bus. This flexibility would avoid problems associated with delays while the disabled bus was removed from the tunnel.

The platform width of 6 m is a desirable platform width based upon the maximum accumulation of passengers at the busy Bank station, and a standard of seven square feet/passenger on the platform. Space is required on the platform to provide for a safety space at the edge of the platform, space for queuing and a space for circulating passengers to reach their bus stop area. At some less busy stations, a lesser width could be tolerated. Some station concepts compromised the platform width where stairs or escalators were located. This happens now, for example, in the Toronto subway, but was felt to be undesirable in this case since passengers will have to circulate along the platform.

### Quality of Construction and Finish

It was accepted as a design objective that the stations would be developed as bright, roomy, pleasant places and that the architectural quality would be consistent with other first class public buildings within the Nation's Capital.

### Geometrics

Stations are to be developed on tangent sections, preferably on a level grade. Cross-sections will be compatible with known requirements for other technology.

Access

All stations are to have stair and escalator capacity to accommodate the appropriate passenger volumes. Elevators are to be provided to assist the mobility impaired in reaching the platform level directly from street level to platform level. Minimum number of grade and direction changes would be desirable.

Fare Control

All stations are to be appropriately designed to allow a full barrier system or a proof-of-payment system. The fare control is to be easily convertible so that operations could change from peak to off-peak periods at the discretion of the operator.

Retail Space

Stations would be permitted to have a small amount of convenience related retail space if warranted and able to be economically located. This space would be related to the needs of the transit passengers and not designed to displace any surface businesses.

Connectivity

The stations should be able to provide, or accommodate integration with other Central Area pedestrian circulation systems. Connections to the Canlands site, the east side of Elgin and north to the Spark Street Mall would be desirable links.

Distribution of Entry/Exit Points

Preferably, the access/egress points to each station should be spread so as to encourage good distribution of passengers and not overload any one access point in the Central Area. The access/egress points may also be located to encourage pedestrian activity in a protected environment along certain axes. This objective must be reconciled with the passenger control requirements of OC Transpo.

Integration

The transit system should be integrated with buildings in the Central Area. To the maximum extent possible, the layout of the stations should encourage this to happen as and when the development opportunities present themselves. The proposed Canlands development is one such opportunity.

Right-of-way Requirements

The station concept should be able, if necessary, to be constructed entirely under the existing street rights-of-way. Stations may be constructed under private property between Albert and Slater Streets, if the property is secured. In the event that no property is available, then the under-the-street design must be able to meet all design requirements. Should a suitable parcel of land be available, then, the station concept can be modified and adapted to this opportunity, and can set the stage for exciting joint use development.

## 14.3 Bank Street Station Concept

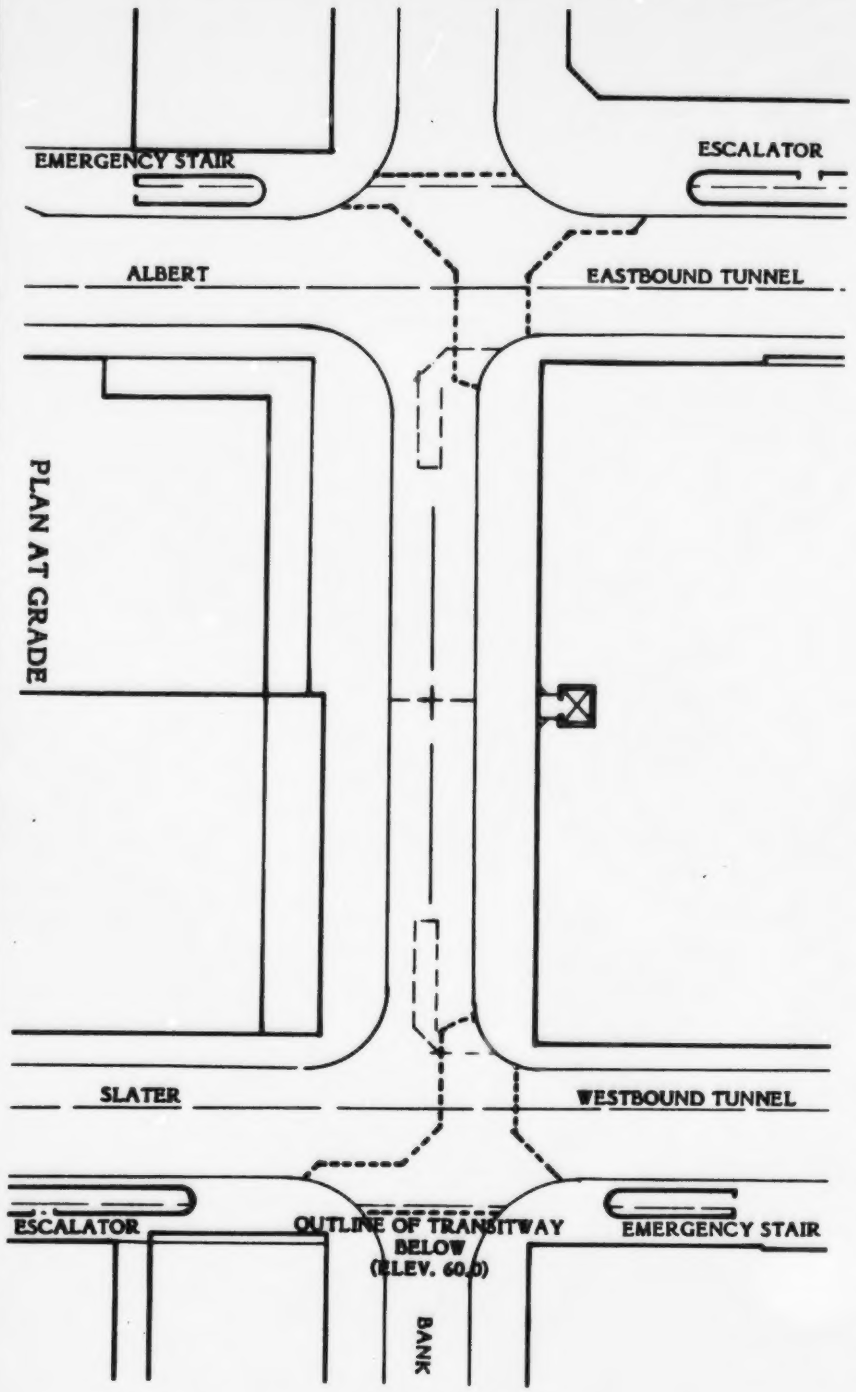
A generic station concept was developed that satisfies most of the design objectives. It is illustrated on **Exhibits 14.1 and 14.2.**

On **Exhibit 14.1,** the first figure "Plan at Grade" indicates the grade level access points. On the north side of Albert Street, on either side of Bank Street, the pedestrian access/egress points are located at street level. These would be canopied entrances on the widened sidewalks or developed into buildings. Similarly, entrances/exits are located on the south side of Slater Street. An elevator location is shown incorporated within the building on the east side of Bank Street.

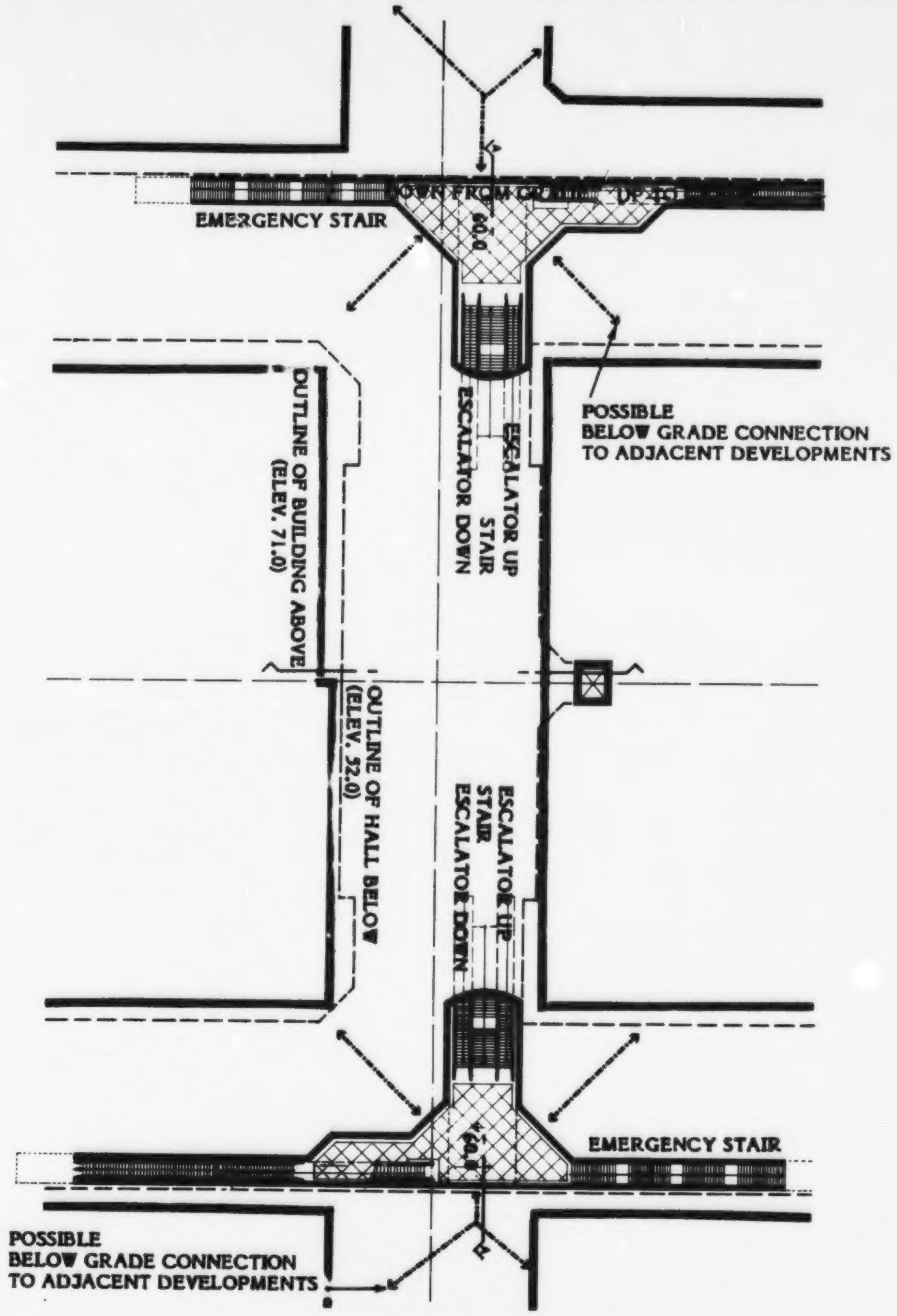
The next figure, "Intermediate Access Level" illustrates the movement from street level to this intermediate level which is approximately at elevation 11 m below the street. Passengers make a 90 degree turn in this concourse area and use the escalators or stairs to the platform level shown as the "Transitway Plan" on the third drawing. Passengers arrive at this level and enter a large domed concourse level. Here, they turn to pass through the fare control area and into the other half of the concourse that leads them to both the eastbound and westbound Transitway platforms.

The cross-section north-south along Bank Street is shown on the first figure on **Exhibit 14.2.** The actual elevations are subject to refinement as more geological information is obtained. It is anticipated that the running tunnels, the cross connecting station, the shafts up to the intermediate concourse and the intermediate level concourse can all be carried out from the initial tunnel excavation, thus avoiding street level disruption until the access shafts are required. Section BB on **Exhibit 14.2** illustrates a cross section looking north

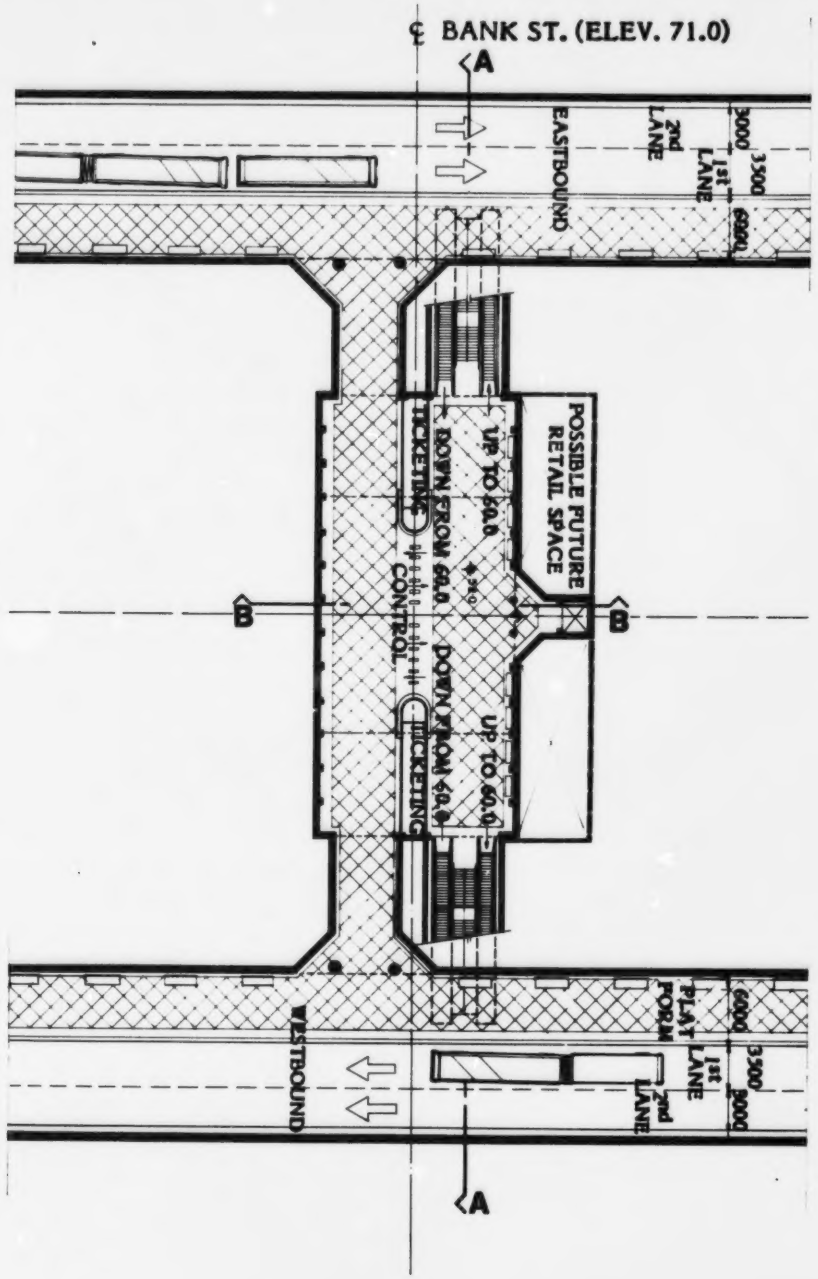
**EXHIBIT 14.1**


EMERGENCY STAIR
ESCALATOR
ALBERT
EASTBOUND TUNNEL
PLAN AT GRADE
SLATER
WESTBOUND TUNNEL
ESCALATOR
OUTLINE OF TRANSITWAY BELOW (ELEV. 60.0)
EMERGENCY STAIR
BANK

PLAN AT GRADE
ELEV. 71.0


DOWN FROM GRADE
UP TO
60.0
EMERGENCY STAIR
POSSIBLE BELOW GRADE CONNECTION TO ADJACENT DEVELOPMENTS
OUTLINE OF BUILDING ABOVE (ELEV. 71.0)
ESCALATOR DOWN
ESCALATOR UP
STAIR
OUTLINE OF HALL BELOW (ELEV. 52.0)
ESCALATOR UP
STAIR
ESCALATOR DOWN
60.0
EMERGENCY STAIR
POSSIBLE BELOW GRADE CONNECTION TO ADJACENT DEVELOPMENTS

INTERMEDIATE ACCESS LEVEL
ELEV. 60.0


℄ BANK ST. (ELEV. 71.0)
A
EASTBOUND
2nd LANE
1st LANE
3000
3500
6000
POSSIBLE FUTURE RETAIL SPACE
UP TO 60.0
DOWN FROM 60.0
TICKETING
CONTROL
DOWN FROM 60.0
UP TO 60.0
TICKETING
B
B
WESTBOUND
PLAT FORM
1st LANE
2nd LANE
6000
3500
3000
A

TRANSITWAY LEVEL
ELEV. 52.0

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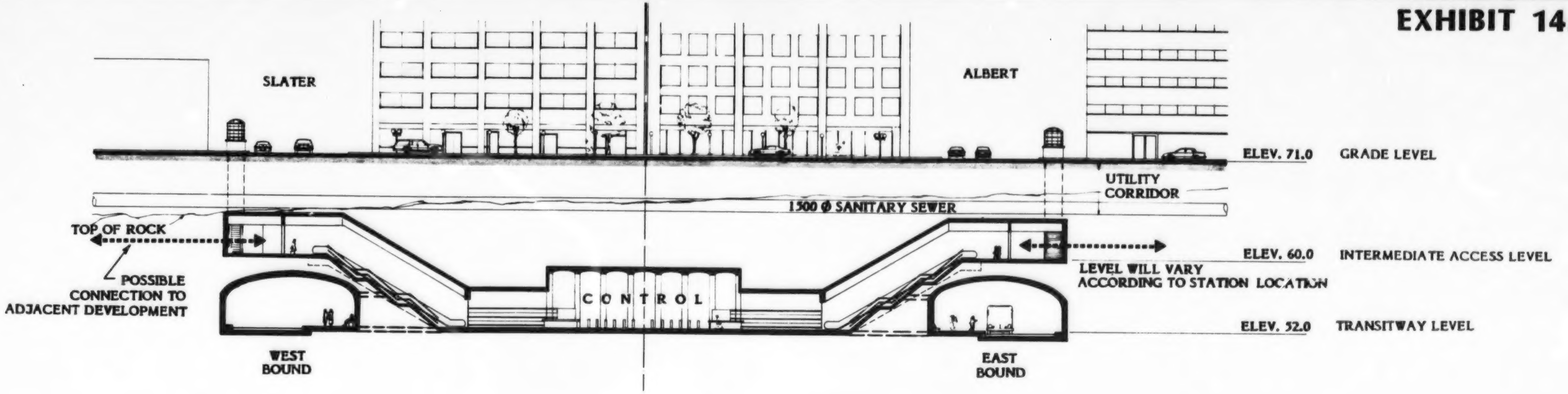
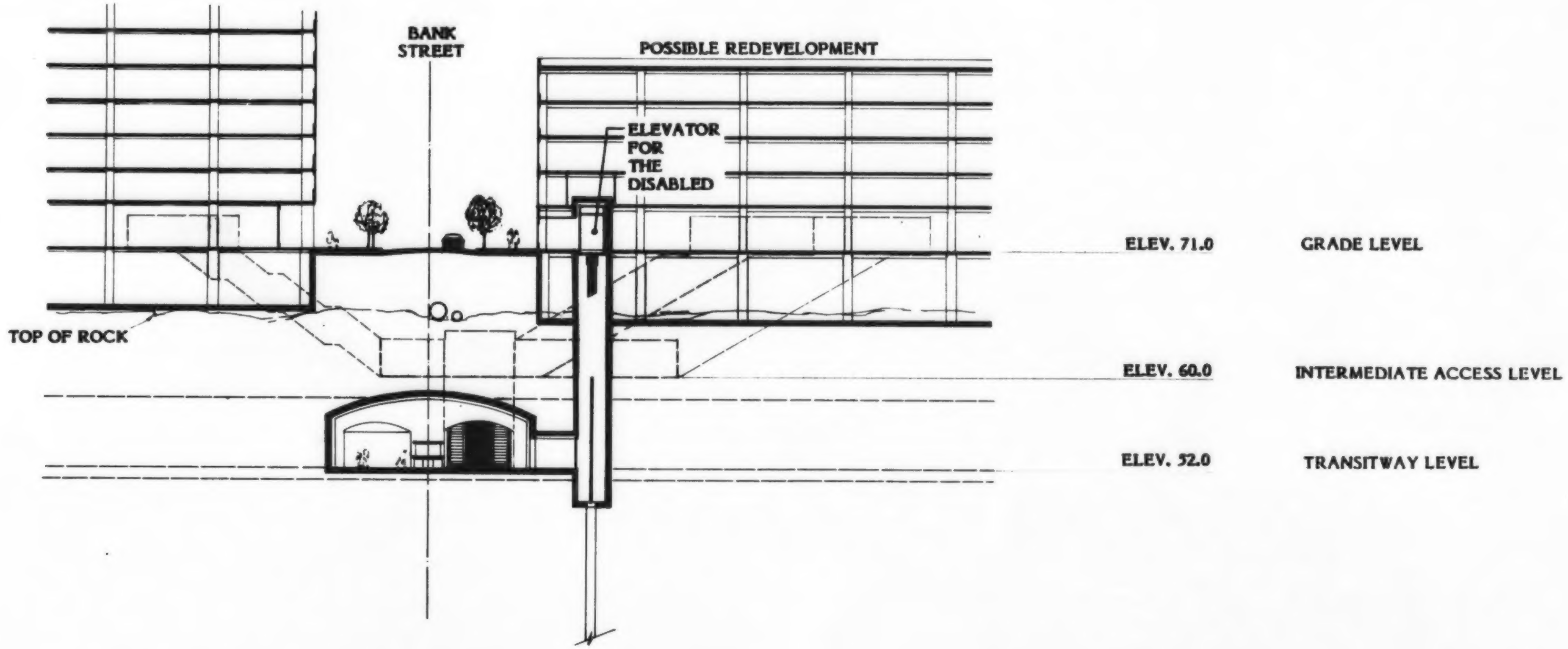
**DELCAN** / GRIFFITHS, RANKIN & COOK

**TUNNEL OPTION**
**BANK STREET STATION**
**ELEVATIONS**

**EXHIBIT 14.2**


SLATER
ALBERT
ELEV. 71.0 GRADE LEVEL
UTILITY CORRIDOR
1500 Ø SANITARY SEWER
TOP OF ROCK
ELEV. 60.0 INTERMEDIATE ACCESS LEVEL
LEVEL WILL VARY ACCORDING TO STATION LOCATION
POSSIBLE CONNECTION TO ADJACENT DEVELOPMENT
CONTROL
ELEV. 52.0 TRANSITWAY LEVEL
WEST BOUND
EAST BOUND


BANK STREET
POSSIBLE REDEVELOPMENT
ELEVATOR FOR THE DISABLED
ELEV. 71.0 GRADE LEVEL
TOP OF ROCK
ELEV. 60.0 INTERMEDIATE ACCESS LEVEL
ELEV. 52.0 TRANSITWAY LEVEL

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**GRADE - SEPARATION FEASIBILITY STUDY**

**DELCAN** / **GRIFFITHS, RANKIN & COOK**

**TUNNEL OPTION**
**BANK STREET STATION**
**SECTION A & B**

along Bank Street. It indicates that the elevator can access the platform level with no need for intermediate stops or changes.

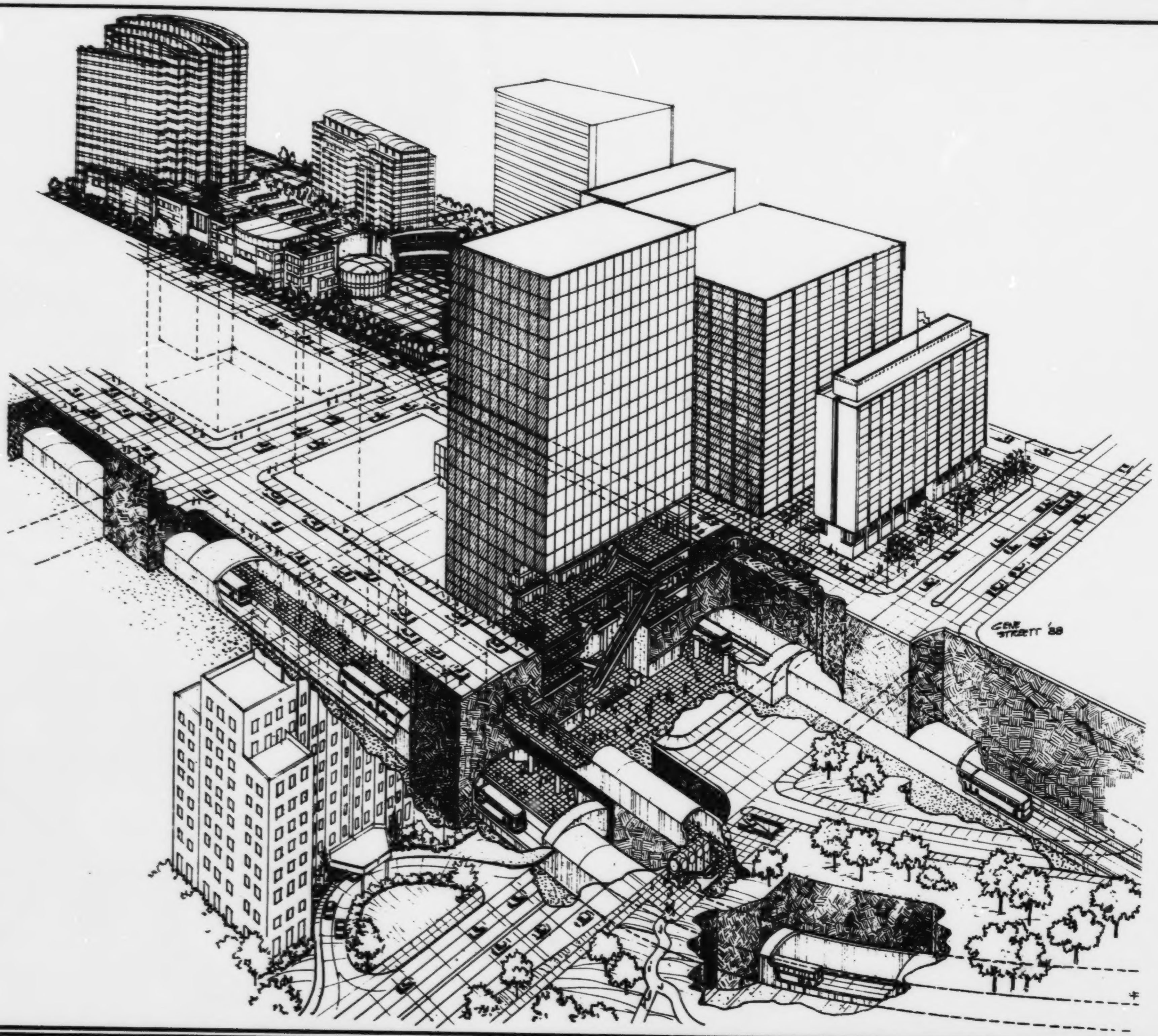
This concept also illustrates the flexibility available to develop other pedestrian connections. From the intermediate concourse level shown on **Exhibit 14.2** Section AA, one can see where pedestrian tunnels can be developed east-west along either Albert or Slater, or further north or south along Bank Street.

This station concept if incorporated under Metcalfe or under the block of land west of the former National Gallery Building (now a parking lot) could provide lateral pedestrian connections east and west to the east side of Elgin Street and to Canlands. At an elevation 10 to 11 m below the street surface, these tunnels could be in rock and access developments at a basement level. Many opportunities are afforded by this concept. It is portable to the location at Lyon Street as well.

**Exhibit 14.3** illustrates concept for joint use development of a station in the Elgin-Metcalfe area. This concept illustrates how joint use development can enhance a Station. It also ilustrates how the pedestrian connection can be made to extend the network to the east of Elgin Street and to Canlands.

Well functioning stations are critical to the success of the Transitway. The opportunities are available to develop exciting stations from the Central Area Transitway and turn them into important nodes of pedestrian activity in the Central Area. It will be important early on in the functional design program to establish the design limits of the stations and protect the property required in order to provide information to the development community that may wish to take advantage of the opportunities for integrated development.

EXHIBIT 14.3



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GRADE - SEPARATION FEASIBILITY STUDY
**DELCAN** /HARRY WEESE & ASSOC.

TYPICAL STATION
INTEGRATION OPTION
METCALFE STATION

# CHAPTER 15

# 15.0 FUTURE WORK

## 15.1 Work to Date

The Central Area Transitway Study covered by this report has been a technical feasibility study. It was designed to provide guidance on the best alignment and method of construction for the Transitway through the Central Area. Because of the large number of options to be examined it was not possible or desirable to go into extensive detail. This can only be done after the preferred option has been confirmed by Regional Council. A feasibility study, by definition, examines the general impacts, requirements and the feasibility of constructing the project.

## 15.2 Functional Design

If the preferred concept as described in this report is adopted by Regional Council as the form and location of a future Transitway through the downtown, then it will be necessary to proceed with further design work at this time regardless of the implementation date. The reasons for doing so are:

a) To sufficiently define the future system so that any developments that occur between now and the actual date of implementation are fully compatible and readily adaptable to integration;

b) To allow the RMOC to take the necessary action to protect any lands that would be required for the construction of the facility;

c) To define the costs for long-term budgeting purposes.

With the feasibility demonstrated and a preferred option selected the next step is Functional Design. Functional Design would examine in detail the preferred option to define the Transitway through the Central Area in terms of plan and profile, station form, entrance locations, right-of-way requirements and project cost. Functional Design will allow intensive costing of the project with a high degree of confidence in the accuracy of the estimates. The construction work would be scheduled and broken down into contract packages. The packages would be based on the disciplines required to complete them and on their dollar value so as to secure competitive and economic contract bids. The Functional Plan will form the basis for the Region to reach a final decision on implementing a grade-separated Central Area Transitway.

## 15.3 Special Studies

In conjunction with Functional Planning and Detailed Design it will be essential or in some cases mandatory to undertake a number of special studies. These studies are required to expand the knowledge of the site, identify potential impacts of the system and provide necessary data for design calculations, cost estimates and construction techniques. The Special Studies include:

### 15.3.1 Studies Required to Support Functional Design

The following studies are required to support the functional design activities:

a) Soils Investigation - Functional Planning

General investigation of the rock quality and rock surface profile along the selected route. This work should start as soon as possible.

b) Field Surveys

Detailed mapping of building basements and foundations, utilities and surface features likely to affect Transitway design and construction.

c) Develop Standards

Preparation and approval of standards to be followed in Detailed Design.

d) Fume Dispersal Study

Preparation of a Wind Tunnel Model of the Central Area to study the dispersal of fumes discharged by ventilation shafts.

e) Architectural Studies

Preparation of station models to show function and appearance of the stations. Displays of selected finish materials for Region approval. Construction of a ventilation shaft mock-up to demonstrate impact on the Transitway route.

f) Ventilation Study

Preparation of a computer model of the Transitway to determine the form and capacity of the Primary Ventilation system.

g) Environmental Studies

Studies of the social, economic and physical impacts of Transitway construction. This will likely be mandatory under the Environmental Act of Ontario.

The work would include public participation and information programs.

h) Operations Study

Studies of Transitway operations through the Central Area including scheduling, control, fleet requirements and equipment selection.

i) Other Special Studies

As the Project proceeds it is likely that other special studies will be required to complete the understanding of the requirements of a grade-separated Transitway in the Central Area.

### 15.3.2 Studies to Support Detailed Design

The following studies are required to support the detailed design activities:

a) Soils Investigation - Detailed Design

More intensive investigation to define soils at specific locations to allow detailed design to proceed.

b) Traffic Management

Preparatory investigation of the management of traffic during construction. This work will require liaison with Police, Fire, Regional and City Departments, as well as OC Transpo.

c) Quality Control Program

Establishing a program of Quality Control for design, construction and equipment procurement.

d) Maintenance Program

Setting up a program for the maintenance of the Central Area Transitway, including procedures, schedules, manuals and staff requirements.

e) Public Information and Central Area Program for Mitigation of Construction Impacts

This will be a very important program and will have to be very carefully structured. Depending upon the method of construction, this program could be very large (cut-and-cover, elevated) or moderate in size with the tunnel option.

## 15.4 Detailed Design

Upon completion of Functional Design, Detailed Design can begin. This phase includes detailed design of structures, systems and the architectural treatment of stations. Contract drawings, specifications and tender documents will be prepared for tendering purposes. Detours and traffic management schemes would be developed as would the public information program. Construction work areas would be defined. A comprehensive cost estimate and project schedule would be prepared.

## 15.5 Operations Research

During the Feasibility Planning Work a computer program (CATSIM) was set up to carry out Operations Research for buses moving through the Transitway. This initial work served to demonstrate that the operations were feasible under a variety of normal and adverse conditions. It would be desirable to continue the Operations Research program to further define Transitway operations under various bus volumes and schedules. Of particular value will be the ability to simulate emergency conditions and study their impact and the steps to be taken to rectify the situation and restore normal transit operations. This model may have merit in being extended to simulate the total Transitway operations in conjunction with other operations planning models at OC Transpo.

## 15.6 Vehicle/Fuel Technology

### 15.6.1 Alternative Fuels

The Primary Ventilation system proposed in the Feasibility Study is capable of handling diesel-engined buses with improved exhaust emissions. Substantial savings in operating costs of the ventilation system could be achieved by the use of buses burning an alternative fuel, such as Compressed Natural Gas (CNG).

Engines fuelled with CNG use spark ignition and operate at a lower compression ratio than diesel-fuelled engines. This results in a reduced noise level for CNG buses, a desirable factor for operation in an enclosed underground environment.

Other bus technology is also promising and could provide alternative choices for transitway buses. Research on dual mode buses has produced the Seattle bus which uses diesel/trolley for propulsion. Rapid developments in battery technology are taking place and hybrid diesel/battery powered buses should also be monitored.

It would be desirable to continue research into the use of CNG for bus fuel as it has important ramifications for tunnel operations. The areas of research required are outlined below. The Ministry of Transportation, Ontario, is currently embarked on a number of programs in this area.

- Availability of suitable engines
- Noise levels of CNG fuelled buses
- Fuelling methods
- Maintenance procedures
- Life-cycle costs of CNG fuelled buses
- Safety of CNG.

## 15.7 Vehicle Selection

Investigations should be undertaken to determine the characteristics of the articulated vehicles to be purchased in the future for operation on the Transitway. Among the areas that should be examined are:

a) Reduced exhaust pollutants.

b) Improved reliability, availability and maintainability of buses.

c) Choice of materials to reduce the fire load and the generation of noxious gases in the event of a bus fire.

d) Improved bus handling for buses to be used in the grade-separated Transitway.

## 15.8 Conversion of Transitway to Another Mode

The Central Area Transitway has been planned to allow future conversion to rail. Among the provisions that would be examined in the functional design would be: pocket in the floor slab for future track installation, sufficient headroom for the installation of traction power overhead, curves and grades suitable for good operation.

The provision of the appropriate headroom for light rail in the underground sections is costly as it increases the overall structural sections and increases the depth of platforms below street level. A study should be undertaken to define the form of the future installation and how the transition from bus to to some future technology is to be accomplished while maintaining transit service to the Central Area. The study should also confirm which type of rail technology is the right choice for future conversion.